METROLINX

Metrolinx Welding Manual

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Preface

This is the second edition of the Metrolinx Welding Manual RC-506-02TRK-01, formerly known as the GO Transit Track Welder Manual. This revision introduces a requirement for ultrasonic testing of new thermite welds with handheld equipment to confirm that defects are not introduced during the welding process. The Metrolinx Welding Manual has also been updated to include detailed descriptions of welding tasks with new figures and tables to improve the readability of the manual.

The Metrolinx Welding Manual document is intended for use by suitably trained and certified railway track welders and professionals. It is not a substitute for coordination and compliance with all applicable local codes, standards, manuals, and approvals for fire protection, life safety, and security measures that are part of the planning, design and implementation of a railway.

Suggestions for revision or improvement can be sent to the Metrolinx Track Standards Committee email at Track.COE.Dept@gotransit.com, Attention: Director, Engineering - Track, who must introduce the proposed changes to the Metrolinx Track Standards Committee. The Director, Engineering - Track ultimately has the deciding vote. Be sure to include a description of the proposed change, background of the application and any other useful rationale or justification. Be sure to include your name, company affiliation (if applicable), e-mail address, and phone number.

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1 General

1.1.1 The instructions, procedures, and practices contained herein apply to all heavy rail trackage and rights-of-way owned by Metrolinx (the Railway) and are intended as the requirements and not meant to replace or supersede the Transport Canada (TC) *Rules Respecting Track Safety* nor any other applicable legislation, regulation, or regulatory requirements.

1.1.2 Metrolinx Engineering and Asset Management (E&AM herein), Director, Engineering – Track is the designated authority for this document.

1.1.3 All new or modified materials or equipment must be subjected to a service test, unless otherwise directed by the Director, Engineering - Track.

1.1.4 No changes to the Welding Manual, or issuance of Bulletins which modify or circumvent the instructions contained herein shall be allowed without the approval of the Director, Engineering -Track.

1.1.5 Under the requirements of this Standard and where appropriate, the Director, Engineering – Track may delegate their authority in writing to a designated individual.

2 Definitions

The following terms and definitions are included below to accommodate usage specific to this document. For terms and definitions not found herein, refer to Metrolinx Track Standards.

2.1.1 **Air carbon arc**: An arc cutting or gouging process where metal is cut and melted by the heat of a carbon arc by a carbon or graphite electrode. Molten metal is then removed by a blast of air. It is also referred to as metal arc gouging and air arc cutting.

2.1.2 **Arc burn**: Localized point of surface melting caused by arcing between an electrode or ground and the component surface.

2.1.3 **Arc flash**: The light and heat produced from an electrical arc supplied with sufficient electrical energy to cause substantial damage, harm, fire, or injury.

2.1.4 **Arc strike**: Discontinuity resulting from an arc, consisting of any localized remelted metal, heat-affected metal, or change in the surface profile of any metal object.

2.1.5 **Austenitic Manganese Steel (AMS):** Steel with a high level of manganese alloying that has a substantially austenitic structure and is characterized as having a high work hardening rate and being non-magnetic or only slightly magnetic.

2.1.6 **Battered end (or rail end batter)**: A flattening down and widening of the rail head at the end of a rail.

2.1.7 **Carbon steel rail**: A high carbon or low alloy steel having pearlitic microstructure.

2.1.8 **Class of track**: The maximum allowable train speed on a subdivision, or portion thereof, as defined by the Transport Canada Rules Respecting Track Safety.

2.1.9 **Closure weld (puller assisted)**: Closure weld is the final weld that joins and adjusts the two rail ends of CWR together.

2.1.10 **Company**: The organization performing welding, including all facilities under common ownership shall utilize the same program of welding standards and documentation.

2.1.11 **Compromise weld**: A thermite weld for uniting two adjacent rail ends of different section sizes.

2.1.12 **Continuous Weld Rail (CWR)**: Rail that is welded into lengths of 400 ft (122 m) or greater, including fixed points between such lengths.

2.1.13 **Contractor**: Individually and collectively, any company, its directors, officers, shareholders, employees, agents, servants, representatives, subcontractors, consultants, and those for whom Contractor is in law responsible.

2.1.14 **CROR**: The Transport Canada Canadian Rail Operating Rules.

2.1.15 **Diamond crossing**: A level intersection where trains may cross over other tracks, at grade. Also referred to as the railway crossing at grade.

2.1.16 **Duty cycle**: The percentage of time during an arbitrary test period that a power source or its accessories can be operated at rated output without overheating. (Example: 60% duty cycle will run/weld 6 minutes out of every 10 minutes.)

2.1.17 **Dye Penetrant (DP) testing**: A non-destructive testing and inspection method, also known as Liquid Penetrant Testing, used to detect surface flaws in material with the use of a cleaner solvent, liquid penetrant, and a developer.

2.1.18 **Electrode burn**: A stress concentrator with metallurgical damage caused by arcing between the flash welding electrode and the parent rail material that may cause the formation of untempered martensite.

2.1.19 **Engine burn:** Damage to the running surface of the rail caused by a slipping wheel.

2.1.20 **Exothermic:** Relates to the liberation of heat during chemical reactions or transformations. An example is the thermite welding process, where the chemical combination of iron oxide and aluminum gives off heat and melts the steel weld metal.

2.1.21 **Field weld:** An in-track or track-side welding process for joining two rail sections, typically by thermite welding or flash butt welding.

2.1.22 **Fire Risk Rating:** A level of fire risk determined and issued daily by the Canadian Wildland Fire Information System (CWFIS). Ratings of HIGH or EXTREME affect these regulations.

2.1.23 **Fire Watch:** A person assigned to observe a location during and after Hot Work.

2.1.24 **Flame clean:** A process used to burn off contaminants or moisture on rail by means of an oxy-fuel gas torch.

2.1.25 **Flangeway:** An opening parallel to a rail to permit passage of wheel flanges.

2.1.26 **Electric Flash Butt (EFB) Weld:** A type of resistance welding that does not use any filler metals. Current is applied to the metal, and the gap between the two pieces creates resistance and produces the arc required to melt the metal, followed by the application of pressure. Flash butt welds provide superior welds to thermite welds and are always to be preferred over thermite welds, whenever possible.

2.1.27 **Flattened rail:** A short length of rail, not at a joint, which has flattened out across the width of the rail head. Flattened rail occurrences have no repetitive regularity and thus do not include corrugations and have no apparent visual cause, such as a weld or engine burn. There are two categories of flattened rail head:

a) **Crushed head:** a flattened rail in which the rail head has drooped into the web area. This is considered a higher-risk defect.

b) **Localized surface collapse:** a flattened rail in which the rail head has not drooped into the web area.

2.1.28 **Flux-Cored Arc Welding (FCAW):** is a fusion welding process, that uses a continuously fed consumable wire electrode to create an electrical arc that

provides the heat necessary to melt the metals being welded. The consumable wire electrode used in flux-cored arc welding is packed with flux.

2.1.29 **Frog:** A track structure used at the intersection of two running rails to provide support for wheels and a passageway for their flanges, thus permitting wheels to transition from one track to another track.

2.1.30 **GO Transit Track Standards (GTTS):** Metrolinx Track Standards referred to as GTTS.

2.1.31 **Guard rail:** A rail or other device laid parallel to the running rail to form a flangeway with the rail. When used with a frog it holds the wheels of equipment in the proper alignment when passing through the frog area of a switch. Guard rails are also laid on bridges.

2.1.32 **Head weld (first or free end of plug rail):** A weld where at least one rail is unfastened or free. This procedure requires no additional rail-pulling equipment and introduces no internal stress to the CWR. If replacing a section of rail, this would be the first weld of a plug rail.

2.1.33 **Hot work:** Any work involving a source of ignition, such as grinding, cutting of rail, thermite welding, welding, etc.

2.1.34 **Inclusion:** Entrapped particles of solid material, such as slag, flux, tungsten, or oxide, that occur in metal or welds.

2.1.35 **Joint bar:** Steel bars that connect adjoining rails. Joint bars are punched with holes to match the end drilling of the rail.

2.1.36 **Luting:** A substance used to seal refractory moulds to the rail in preparation for a thermite weld.

2.1.37 **Magnetic Particle Inspection (MPI):** Is a non-destructive testing process for detecting surface and subsurface discontinuities in ferromagnetic materials. The process puts a magnetic field into the part. A magnetic flux is applied to the area being tested to detect flaws.

2.1.38 **Manufacturer:** The original builder, fabricator, or installer of equipment, as well as any company or organization performing repairs or alterations to such equipment.

2.1.39 **Martensite:** Martensite is formed when steel is heated above the A1 critical temperature (approximately 1300 °F to 1400 °F (704 °C to 760 °C) or higher) and cooled rapidly below the martensite start temperature, such that the formation of diffusional austenite decomposition products, such as pearlite, is absent or incomplete. In untempered conditions, especially in high-carbon steels, martensite is hard, brittle, and generally undesirable in locations of the rail subjected to high cyclic mechanical stress.

2.1.40 **Match marks:** Marks placed on the base of the rail, in a straight line, and the top of a tie plate on an unanchored tie. They are used when destressing rail to ensure that rail has moved the required amount.

2.1.41 **Owner:** The individual or company that exercises legal ownership of the product or structural assembly produced under this specification.

2.1.42 **Pin brazed bonds:** An arc brazing process, which bonds electrical connectors to rails.

2.1.43 **Plant weld:** A flash butt weld made in a fixed stationary plant location for the purpose of forming CWR strings that will be transported to a field location for installation in track.

2.1.44 **Personal Protective Equipment (PPE):** Mandatory everyday apparel and/or specialized, mandatory task-specific apparel designed to protect employees and visitors.

2.1.45 **Preferred Rail Laying Temperature (PRLT):** The target installation temperature of welded rail in a particular area.

2.1.46 **Rail Neutral Temperature (RNT):** The temperature at which the rail is neither in tension nor compression.

2.1.47 **Rail puller/expander**: A device used to overcome the extreme contraction or expansion forces present in continuous welded rail due to the effects of temperature. It is designed with a hydraulic system capable of holding rail end gaps for long periods of time, such as is required during the performance of thermite welding operation.

2.1.48 **Rail signal bond (signal bond, track circuit bond, bond wire, rail bond):** A conductive connection between adjoining rail ends to facilitate the track circuit.

2.1.49 **Rail Traffic Controller (RTC):** An employee in charge of the supervision and direction of movements and for the provision of protection for track work and track units on a specified territory.

2.1.50 **Rail gap:** An opening created in preparation for a thermite weld.

2.1.51 **Red zone:** The danger area is defined as 15 ft (4.6 m) along the rail from each end of the puller and along the length of the puller itself.

2.1.52 **Reference marks:** These are a pair of vertical lines, each placed approximately 5 ft (1.524 m) away from a joint or planned rail cut, at opposing ends of a rail repair, used to check whether rail was added or removed from the track.

2.1.53 **Shear gouge:** A stress concentrator created during the shearing process following thermite or flash butt welding caused by improperly adjusted shear dies or misalignment of the rails.

2.1.54 **Shear smear:** A stress concentrator created during flash butt welding shearing caused by improperly dressed shear dies or misalignment of the rails.

2.1.55 **Shear tear:** A displacement of thermite welding material extending below the rail contour caused by the shearing of the weld too early.

2.1.56 **Shielded Metal Arc Welding (SMAW):** Also known as stick welding, it is a manual process that uses a flux-coated consumable electrode with a metal rod at the core.

2.1.57 **Stock rail:** A running rail immediately adjacent to a switch point against which the switch point lays when in the closed position. Stock rails are ordinary rails

that have been machined, drilled, and bent as required to suit the design of the switch.

2.1.58 **Switch:** A device consisting of two movable rails, necessary connections and operating parts designed to turn a train from one track to another track.

2.1.59 **Switch point:** A movable rail used in a switch for diverting a train from one track to another.

2.1.60 **Switch point guard:** A rail or other structure laid adjacent to a switch point to hold wheels in correct alignment to prevent the wheel flange from striking the tip of the switch point.

2.1.61 **Weld kit:** A set of disposable materials used in the installation of a thermite weld.

2.1.62 **Wing rail:** In bolted rigid frogs, spring frogs, and Movable Point Frogs (MPF), it is the rail on either side of the frog point rail. In a Rail Bound Manganese (RBM) frog, it abuts the manganese casting.

2.1.63 **Thermite weld:** A process that employs molten metal to permanently join the conductors (rail). The process utilizes an exothermic reaction of a thermite composition to heat the metal and requires no external source of heat or current. The chemical reaction that produces the heat is an aluminothermic reaction between aluminum powder and metal oxide.

3 Safety

3.1 Safety Requirements for Track Welders

3.1.1 Safety is the most essential aspect of any job. Understanding and following safety rules and safe work practices is a condition to work on Metrolinx property. When in doubt, employees must take the safest course of action.

3.1.2 The title Welder, as used in this Metrolinx Welding Manual, is intended to include Welding Foreman, Welder, Welder Helper, Welder Trainee, and those individuals trained and certified to operate any welding, grinding or oxygen fuel gas cutting equipment.

3.1.3 Extreme caution must be exercised to prevent injury and assure weld quality. This means being compliant with all rules, procedures, practices, and guidelines. Safety is a direct reflection of the Welder's knowledge, skill, determination, and attitude. Taking the time to do the job right once, will prevent injury to yourself or others.

3.1.4 All Employees and Contractors are responsible to know, understand, and comply with all current Metrolinx and Manufacturer rules, guidelines, procedures, and practices related to the job task(s).

a) Job tasks must only be performed by individuals who are authorized, trained, and certified to perform them;

b) Comply with all local, provincial, and federal government laws and regulations that relate to our job task(s), including but not limited to:

i. Motor vehicle operation;

ii. Transport of welding gasses; and

iii. Fire protection restrictions, including Transport Canada's Railway Extreme Heat and Fire Risk Mitigation Rules.

c) Know, wear, and maintain approved PPE and clothing as required by job task and/or the work environment;

d) Only use approved tools, equipment, and materials for the purpose(s) intended. Unauthorized modifications, overrides to safety devices, and removal of safety guards are prohibited; and

e) Inspect all tools, equipment, and related safety devices for unsafe conditions before use. Remove from service if defective.

3.1.5 It is the responsibility of the Welder to train and familiarize Welder trainees, Welder helpers, and track labourers working with or around welding operations in all hazards and safety applications of welding processes.

3.1.6 Welding, grinding, and cutting will be done only by or under the direct supervision of a trained and certified person. There are several categories of

track welding used by Metrolinx. Employees or Contractors must not do or supervise work in any category for which they are not trained and certified.

3.1.7 Positive track protection must be obtained prior to any welding, cutting, or grinding on live track. It is the welding crew's responsibility to know the type of protection being provided in accordance with the Operating Rules.

3.1.8 A minimum of a two (2) person crew is mandatory for all aspects of Track Welding. This includes assisting the Welder as a Safety and Fire Watch.

3.1.9 All aspects of track welding are considered "Hot Work" which means any work involving a source of ignition, such as grinding, cutting of rail, thermite welding, welding, etc. These activities must include a fire prevention and response plan.

a) Monitor fire risks using the CWFIS daily and advise when the Fire Risk Levels are "High", "Very High", or "Extreme". The Fire Risk Levels will be consistent with the definitions from the CWFIS as described in Table 3-1. No Hot Work is to be performed when the fire risk is High, Very High, or Extreme.

b) If the CWFIS map is not available or the fire risk is unknown, the risk must be considered, at minimum, to be a moderate risk level. If more than one Fire Danger Level is shown for the area where work is being performed on the CWFIS interactive map, the highest indicated level will be used.

c) A Right-of-Way and Bridge Fire Risk Assessment, Mitigation and Response must be completed.

Table 3-1: Description of Fire Danger (risk) Levels as per Information Provided by CWFIS

Fire Danger Status	**Description** (Reference: http://cwfis.cfs.nrcan.gc.ca/maps/fw)
Low	Fires likely to be self-extinguishing and new ignitions unlikely. Any existing fires limited to smouldering in deep, drier layers.
Moderate	Creeping or gentle-surface fires. Fires easily contained by ground crews with pumps and hand tools.
High	Moderate to vigorous surface fire with intermittent crown involvement. Challenging for ground crews to handle; heavy equipment (bulldozers, tanker trucks, aircraft) often required to contain fire.
Very High	High-intensity fire with partial to full-crown involvement. Head fire conditions beyond the ability of ground crews; air attacks with retardant required to effectively attack fire's head.
Extreme	Fast-spreading, high-intensity crown fire. Very difficult to control. Suppression actions limited to flanks, with only indirect actions possible against the fire's head.
Nil	No calculations were performed.

3.1.10 Specific tasks which could contribute to fires include: cutting rail, welding, thermite welding, rail grinding by hand, rail destressing by heating the rail, use of a rail grinding train, and controlled burning of brush.

3.1.11 Third parties or contractors are required to provide their safe-work procedures to the Metrolinx E&AM – Track prior to commencing work. Those procedures include measures to be taken to prevent fires and to perform Hot Work safely for employees, the public, and the environment.

3.1.12 A job briefing is performed by the Track Supervisor or employee in charge on site. These briefings take place at the start of each shift, and when there are changes in conditions on-site or changes to how work will be performed. The purpose of the job briefing is to inform workers and all other people on site regarding, but not limited to, the following:

a) The nature of work to be performed, individual responsibilities and work methods that are to be followed;

b) The type of protection provided for track work (including work limits and duration of work permit);

c) Hazards associated with the work that will take place, including safe work procedures, tools/ equipment required to perform the job/task safely (provided by third-party) and the location of safety equipment, as well as the location of the muster point in the event of an evacuation;

d) Special hazards (fire risk level, high-risk work, working at heights, etc.);

e) Fire control procedures and assignment of responsibilities;

f) The emergency contact numbers and communication procedures;

g) Other information related to the protection of workers or other people involved on-site; and

h) Prior to beginning work, the Track Supervisor or employee in charge on-site must review the requirements for the fire risks (see Table 3-2) to ensure the required equipment is available and confirm with the Metrolinx Site Representative that notifications have been provided as warranted.

Table 3-2: Equipment Requirements by Fire Hazard

FIRE HAZARD RATING AND EQUIPMENT REQUIRED		
Work Description	Low (Fire Danger)	Medium (Fire Danger)
Routine track work along right-of-way involving cutting, welding, and grinding	• 2 round-nose shovels • 2 Pulaski axes • 2 backpack sprayers • Firewatch – 30 minutes minimum	• 2 round-nose shovels • 2 Pulaski axes • 2 backpack sprayers • Firewatch – 1 hr minimum
Hot Work on a bridge	**Notify Local Fire Department** • 2 round-nose shovels • 2 Pulaski axes • 4 backpack sprayers • 90 gal (340 l) total water pump and 100 ft (30 m) of hose and nozzle • Spark screen/mats • Firewatch – 1 hr minimum • Verify during track inspection	

3.1.13 All Welding Foreman, Welders, Welder helpers and Welder trainees must carry a copy of the site-specific Right-of-Way and Bridge Fire Risk Assessment, Mitigation and Emergency Response. They must know and understand its contents as this pertains to their work.

3.1.14 During Hot Work, measures must be taken to prevent the spread of sparks, slag, and other sources of ignition to adjacent flammable or combustible materials such as vegetation, trees, shrubs, or materials present in the environment:

a) Ensure that all equipment is in good operating order before starting work;

b) Ensure that all appropriate personal protective devices are available at the site and each worker has been trained on how to inspect, use, maintain, and store them properly;

c) Inspect the work area thoroughly before starting, look for combustible materials adjacent to track (vegetation, materials, debris, etc.) and remove or cover as required;

d) Install fire retardant barricades for sparks, slag and other sources of ignition;

e) Use water only if electrical circuits have been de-energized to prevent electrical shock;

f) Move all flammable and combustible liquids at least 20 ft (6 m) from any source of ignition;

g) Cover any combustibles, that cannot be moved, with fire-resistant blankets or shields;

h) Protect all equipment from exposure to sparks, hot materials and other objects which could cause an ignition;

i) Wet down surrounding surfaces, such as vegetation, if they cannot be adequately covered and pose a risk of fire due to the tasks to be performed;

j) Ensure underground services such as pipes for gas or petroleum products (for rail switch heaters, etc.) have been located and marked. If they are present in the path of sparks or hot materials, their presence must be made known, and authorization must be obtained from the owner of the underground service and from the Metrolinx E&AM – Track prior to beginning work;

k) Do not perform fueling operations near the Hot Work area. Keep fueling operations a minimum of 20 ft (6 m) away;

l) Ensure that appropriate fire extinguishers (e.g., backpack sprayers, 20 lb (9 k) ABC fire extinguishers, pump and water supply) are available in the work area and easily accessible if required;

m) Ensure that the first aid boxes are available in the work area and easily accessible;

n) Inspect the area following work to ensure that smouldering or small fires have not started; and

o) Post a trained Fire Watch within the work area during welding, including during breaks, and for at least 30-60 minutes after work has stopped. Depending on the work done, the area may need to be monitored for longer (up to three hours) after the end of the Hot Work, depending on the fire risk level previously mentioned. The Fire Watch must be capable of taking immediate measures to extinguish or report the fire.

3.1.15 Wear the proper personal protective equipment (PPE), which gives full body protection during all welding, cutting, and grinding operations:

a) Wear metal, aluminum, or rigid plastic leggings for surface grinding with plate-mounted or cup wheels. When combination leggings (welding leggings) are available, they may be used for all grinding, sawing, and torch-cutting procedures. Metal aluminum, rigid plastic, or leather leggings must be used for other grinding work;

b) Keep clothing free of grease, oil, and other flammable materials. When performing these operations, employees must keep shirt sleeves rolled down and collar fastened. Caution must be exercised at all times to keep sparks or slag from being caught in cuffs, pockets, sleeves, under gloves, and out of work boots, eyes, and ears. Unsuitable clothing such as T-shirts, shorts, etc., or torn/frayed clothing must never be worn. Synthetic fabrics such as rayon, nylon, polyester, acrylic, etc., are readily combustible and must never be worn;

c) Wear welding gloves during any welding, cutting, or grinding procedure.

3.1.16 Wear safety glasses at all times. Employees observing, working near, or performing any grinding, welding, or cutting operations must wear necessary approved face shields, helmets, goggles with approved lenses, and cover glasses.

3.1.17 Ensure that the correct lens shade for the type of welding, heating, cutting, or gouging operation being performed is used. This is the Welder's responsibility:

a) Use a minimum No. 10 lens shade for electric track welding SMAW and/or FCAW;

b) Use a minimum No. 5 lens shade for thermite welding pre-heating operation, torch cutting up to 6 in (152 mm) plate, and torch cutting rail; and

c) Use a minimum No. 12 lens shade for arc-air gouging or cutting.

Note: Welding lens shades are not additive. For example, a No. 3 shade safety glass and a No. 9 shade in a welding helmet do not have the same effective protection as a No.12 lens shade. UV eye protection is only rated for the highest-rated number lens. In this example, it is the No. 9 lens shade.

3.1.18 When using adjustable auto-darkening welding hoods/helmets:

a) It is the Welder's responsibility to maintain the helmet, lens, and batteries; and

b) Have extra batteries on hand to prevent eye injury and downtime.

3.1.19 Wear clothing suitable for the welding apparatus being used and for the type of Hot Work being performed. For hand or wrist protection, leather gloves must be worn. Fire-resistant clothing is required. Materials like Nomex, Kevlar, and Modacrylic may be used when required.

3.1.20 All welding crews must have and maintain an adequate first aid kit appropriate for the crew size. It must include burn kit supplies.

3.1.21 Welding and/or cutting should not be done near combustible material. If possible, the work or the combustible material should be moved to a safe place.

3.1.22 Use of cutting or welding equipment to perform maintenance work on or in a structure without the knowledge or authorization of the person in charge of the structure is prohibited.

3.1.23 Use a guard of sheet metal or other non-combustible material when welding or cutting close to wooden beams, partitions, flooring, or scaffolding. Use fire-resistant guard curtains (not tarpaulins) large enough, tight, and weighted down to prevent sparks from rolling underneath or through openings:

a) Take every precaution to provide suitable protection against flying sparks;

b) Carefully clean all surfaces in the area before work is started. Surfaces should be of any readily ignitable material; and

c) Wet down any combustible surfaces, such as floors, partitions, etc., before the operation is started, and constantly kept wetted while the work is ongoing.

3.1.24 Assign a "Fire Watch" to extinguish fires started by sparks, molten metal, or hot slag. Inspect carefully the area where Hot Work has been performed and before leaving the work area to detect and extinguish any live sparks or smouldering fires.

3.1.25 Have suitable fire extinguishers, readily accessible, in ample numbers and in close proximity to where the equipment is being used, to provide a quick response. Before beginning grinding, if a water hose is provided, the off-track area must be dampened with plain water and have a hose at the ready for possible flare-up fires.

3.1.26 Beware of smoke, and avoid being in the line of smoke, so as not to breathe it in. If available on the welding truck in use, the 12-volt pump sprayer must be kept in good working order. If the 12-volt pump sprayer is not available, a 5-gallon (19-litre) portable fire pump with a water sprayer is the best substitute. Always spray from the ballast line when possible.

3.1.27 The use of cutting and/or welding equipment, in the performance of maintenance work in structures containing combustible materials, must be avoided. Where the use of welding or cutting equipment is permitted in these facilities, every precaution must be taken to minimize the risk of fire. The Track Supervisor will be contacted to assign someone to patrol the area for several hours after the Hot Work ceases as a "Fire Watch."

3.1.28 Position welding equipment so that flames and sparks do not fall on cylinders, hoses, electric welding cables, hydraulic hoses, and other equipment.

3.1.29 Comply with Metrolinx and government regulations regarding the use of lifelines, safety belts, or other safeguards as protection against falling, when working on bridges, scaffolds, platforms, and other such work areas higher than the surrounding ground.

3.1.30 Don't weld or cut from any platform suspended by rope subject to burning or damage by fire.

3.1.31 Inspect tools and equipment for defects prior to use. If found defective, they must be repaired or adjusted for safe operation or removed from service, tagged defective and reported to your immediate supervisor.

3.1.32 Don't use hands, whether gloved or otherwise, to brush slag or metal from material being welded or cut.

3.2 Welding In Confined Spaces

3.2.1 Welding or cutting rail in confined spaces is prohibited on Metrolinx property.

3.3 Respirators

3.3.1 Welding fumes regulatory limits and occupational exposure limits, as defined by ACGIH, OSHA, and NIOSH, for key metal analytes associated with industry welding activities are referenced below. Canada relies on ACGIH for guidance on occupational exposure values. Due to the recent (2018) ACGIH reductions in exposure limits, including chromium and hexavalent chromium, certain analytes are regulated more stringently in Canada as compared to the U.S.:

Table 3-3: Comparison of Exposure Limits

Metal Analyte	ACGIH LTV (mg/m3)	OSHA PEL (mg/m3)	OSHA STEL/C (mg/m3)	NOISH REL (mg/m3)	NOISH STEL/C (mg/m3)
Chromium	0.5 (inhalable)	1.0		0.5	
Hexavalent Chromium	0.0002 (inhalable)	0.005		0.0002	
Iron Oxide	5 (respirable)	10 (fume)		5 (dust and fume, as Fe)	
Manganese	0.02 (respirable) 0.1 (inhalable)		5 (C)	1.0	3.0

a) Provide adequate ventilation when welding or cutting certain metals or using certain welding rods or fluxes, as toxic fumes may be produced. Among the metals or items that may produce toxic fumes are beryllium, brass, bronze, cadmium, chromium, fluxes containing fluorides, galvanized iron, lead, lead-based paint, manganese, mercury, and zinc;

3.3.2 Always use a respirator when welding, cutting, or grinding on manganese track components.

3.4 Transporting Welding Tanks on Public Roadways

3.4.1 Metrolinx requires all vehicles (working for or contracted to Metrolinx) that carry compressed gas cylinders to be marked to indicate that they comply with all applicable specifications and regulations of the Federal Canadian Transportation Commission rules, and Workplace Hazardous Materials Information System (WHMIS).

3.4.2 Ensure that all vehicles transporting welding cylinders (tanks) or (materials of trade) that operate on any public roadway comply with the following:

a) All welding cylinders (tanks) are securely fastened in an upright position;

b) Vehicles where gas cylinders (tanks) are carried in an enclosed compartment (cabinet/locker), are properly vented. Openings/vents are required on both the top and bottom of the compartment (cabinet/locker);

c) All vents are open and clear of obstructions, allowing proper ventilation and any leaking oxygen or fuel gas (propane or acetylene) to disperse freely;

d) Safety Note:

i. Propane is heavier than air and will sink to the bottom.

ii. Acetylene is lighter than air and will rise to the top.

e) The cylinder (tank) valves are closed, and all pressure is released from the system;

f) All cylinders (tanks) that have (or require) a valve protection cap have the pressure regulator gauges removed and original cylinder cap in place;

g) Regulators (gauges) are removed from the tanks prior to operation on any public roadway;

i. The protective cylinder (tank) valve caps are in place and securely installed to protect the tank valve; and

ii. The regulators (gauges) are properly stored to protect from damage;

h) The regulators (gauges) may stay on the cylinder (tank) valves while working on Metrolinx property: the vehicle may be moved or operated to complete a series of operations where the torch is required or in use:

i. Regulators (gauges) are removed from the cylinder (tank) at the end of every workday or shift;

ii. The protective cylinder (tank) valve caps are in place and securely installed to protect the tank valve; and

iii. The regulators (gauges) are properly stored to protect from damage.

i) The Welder or operator must inspect and perform a Leak Test on the equipment. This must be completed prior to the first initial use, daily.

3.4.3 **Safety Note**: Improper storage, transporting or handling of welding compressed cylinders can result in tragedy, injury, or death.

3.4.4 Properly vent any vehicle with an enclosed compartment (cabinet/locker) for carrying gas cylinders (tanks). Provide openings/vents on both the top and bottom of the compartment (cabinet/locker):

a) Keep vents open and clear of obstructions to allow proper ventilation, which will allow any leaking oxygen or fuel gas (propane or acetylene) to disperse freely.

3.4.5 Remove regulators (gauges) from the cylinders (tanks) at the end of every workday or shift, then:

a) Ensure that the protective cylinder (tank) valve caps are in place and securely installed to protect the tank valve; and

b) Store the regulators (gauges) properly to protect from damage.

3.5 Oxygen and Fuel Gas (Propane/Acetylene) Cutting, Heating and Welding Safety

3.5.1 Advancements in techniques and new processes will be developed. It is, therefore, most essential that the directions and rules for operating and maintaining welding and cutting apparatus, which are furnished by the manufacturers of these commodities, be followed closely:

a) It is the responsibility of the Operator (Welder) to know and understand the safe operation of the type of equipment they are using; and

b) Only trained and certified personnel are allowed to operate oxygen and fuel gas apparatus.

3.5.2 Always refer to the proper name of the fuel gas you are using, such as propane, acetylene, MAPP (stabilized methylacetylene-propadiene), etc.

3.5.3 Don't, under any circumstances, attempt to transfer any type of fuel gas from one cylinder to another, or to mix any other fuel gas with it in the cylinder.

3.5.4 Refilling of any oxygen or fuel gas cylinders (tanks) must only be done by the manufacturer or supplier, and by trained personnel.

3.5.5 Always refer to oxygen by its full name "oxygen" and not, for example, by the word "air". A severe accident may easily result if oxygen is used as a substitute for compressed air.

3.5.6 Never use oxygen for any purpose other than welding. Do not use oxygen in pneumatic tools, to start engines, to blow out pipelines, or to "dust off" clothing or equipment.

3.5.7 Keep oil and grease away from all cylinders (tanks), cylinder valves, regulators (gauges), hoses, and hose connections. Grease and/or oil, when combined with oxygen, is a highly explosive mixture.

3.5.8 Always use flashback arrestors at the torch end of all oxygen and fuel gas (propane/acetylene) welding, cutting, and heating apparatus. Some manufacturer's models may have built-in flashbacks and check valves.

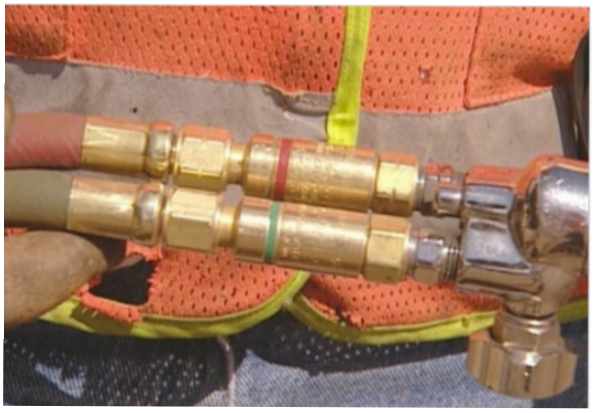


Figure 3-1: Flashback Arrestors
Courtesy CN Training

3.5.9 Use type T grade 3/8 in (96 mm) diameter gas hose for oxygen/fuel:

Note: T grade hose is approved for all fuel gas use.

a) Use a maximum hose length of 100 ft (30.5 m); and

b) When using thermite preheating equipment, use a maximum hose length of 50 ft (15 m).

3.5.10 Don't use quick disconnect hose couplings. These are not allowed to be used.

3.5.11 Make hose repairs and connections using only feral crimped connectors:

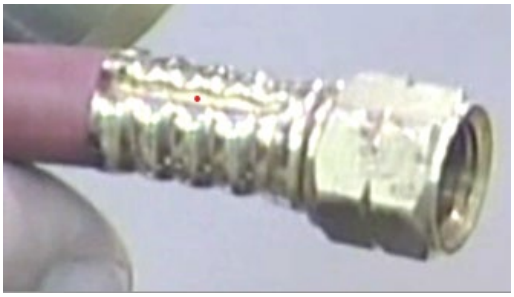


Figure 3-2: Crimped Feral Hose Connector
Courtesy CN Training

a) Use no more than two (2) splice connectors within the 100 ft (30.5 m) length;

b) Never attempt to repair hoses with friction tape, hose clamps, or other types of wire.

3.5.12 Do not use Teflon tape or pipe dope on any of the torch systems compression fittings, including regulator to cylinder valve connection, flashback arrestors, reverse flow check valves, test gauges, hose connections, etc.:

a) Never force connections that do not fit. If excessive force is used to tighten connections, the seat may be marred, and the threads and nuts become distorted.

3.5.13 Perform a pressure leak test of the oxygen fuel gas apparatus system at a minimum of once prior to initial use each day. Follow this procedure to pressure leak test the system:

a) With the oxygen cylinder valve open, adjust the oxygen regulator to deliver 20 PSIG;

b) With the fuel gas cylinder valve open, adjust the fuel regulator to deliver 10 PSIG;

c) Ensure that both oxygen and fuel gas control valves on the torch handle are closed;

d) Close both the oxygen and fuel gas cylinder (tank) valves;

e) Turn the adjustment screw (T handle) on the regulator, counterclockwise one (1) turn;

f) Observe the gauges on both regulators for 3 to 5 minutes. If the gauge readings do not change, then the system is leak-free;

g) If there is a pressure drop on any of the gauges, there is a leak in the system;

h) Use an approved leak test solution, or an oil base free soap/water solution, (Ivory soap is oil-free) and check all fittings and connections for leaks;

i) If the leak cannot be found, do not use the system until the system is repaired or replaced and is determined to be leak-free; and

j) If a system is determined to be leak-free, open the cylinder (tank) valves and proceed with the work.

3.5.14 Ensure that compressed gas cylinders (tanks) are secured at all times. Compressed gas cylinders (tanks) are safe for the purpose for which they are intended but must not be abused or mishandled.

a) Keep protective equipment dry and free of oil; and

b) Do not carry matches or other combustible material such as butane lighters, etc., while doing any welding.

3.5.15 Track Welders are not allowed to weld, cut, or grind on any container or drum.

3.6 Emergency Shut Down in Event of Flashback

3.6.1 Follow this procedure in the event of an internal torch fire or flashback (identified by a whistling sound or an inverted flame):

a) Turn off the oxygen torch valve immediately;

b) Turn off the fuel gas torch valve;

c) Turn off the oxygen cylinder (tank) valve;

d) Turn off the fuel gas cylinder (tank) valve; and

e) Do not relight the torch until the equipment has cooled to the touch and the flashback situation has been determined and corrected. Equipment replacement may be necessary.

3.7 Hydraulic Equipment Safety and Risks

3.7.1 Hydraulic equipment and tools are allowed for use across Metrolinx's network. Hydraulics use incompressible fluid, which results in more efficient and consistent work or power output. Fluid can stand high heat and sustain its viscosity, density, and temperature. Hydraulics can transfer a significant amount of power through small tubes and flexible hoses. Hydraulics are more powerful than electrical equipment of the same size. Motion can be almost instantly reversed.

3.7.2 All Welders must be trained in the safe operation of the hydraulic equipment, machines, and tools assigned to them. Welders must be aware of minor troubleshooting remedies. Prior to initial use, the operator must make daily checks and inspections of all fluid levels and maintenance requirements, following the manufacturer's instructions.

3.7.3 Not following the hydraulic safety rules can cause injuries, death, equipment damage, and even environmental damage.

a) Welders must:

i. Read safety instruction manuals, tags and labels of the hydraulics;

ii. Use the hydraulic equipment for its intended purpose only;

iii. Check their equipment daily;

iv. Keep hoses away from traffic areas, sharp edges, moving parts, and hot surfaces; and

v. Comply with all local or national fire, electrical and safety regulations.

b) Welders must not:

i. Modify or alter the hydraulic equipment;

ii. Exceed maximum working pressure;

iii. Use hoses to pull equipment; and

iv. Put fluid in any system not specifically designed for that fluid.

3.7.4 Injection injury is not a well-recognized safety hazard and is hard to diagnose. It can occur from a pinhole leak in a line as pressurized fluid travels at bullet speed. This fluid can also be toxic or hot. This type of injury can result in amputation or even death. Take injection injuries seriously. Seek immediate medical attention. Tips to prevent injection Injuries:

a) Do not point the dispensing valve at anyone or any part of the body;

b) Do not put your hands or fingers over dispensing valve;

c) Do not try to find, stop or deflect a leak with your hand, body, glove or rag;

d) Use only extensions and nozzles designed for the dispensing valve;

e) Tighten all fluid connections before use;

f) Check hoses, tubes, and couplings daily; and

g) Seek medical attention immediately in case of any contact, puncture, or injection.

3.7.5 Puncture injection wounds may only seem like a sharp pin prick or sting. When seeking medical attention, explain in full detail to the Emergency Room Physician what you were doing and that you may have a high-pressure hydraulic injection injury.

3.8 Electric Arc Welding Equipment Safety and Risks

3.8.1 Touching live electrical parts can cause fatal shocks or severe burns. The electrode and work circuit are electrically live whenever the output is on. The input power circuit and machine internal circuits are also live when power is on. In semi-automatic or automatic wire welding, the wire, wire reel, drive roll housing, and all metal parts touching the welding wire are electrically live. Incorrectly installed or improperly grounded equipment is a hazard.

3.8.2 All Welders must be trained in the safe operation of the electric welding equipment, machines, and tools assigned to them. Welders must be aware of minor troubleshooting remedies. Prior to initial use, the operator must make daily checks and inspections of all fluid levels and maintenance requirements following the manufacturer’s instructions.

3.8.3 Avoidance of electric shock is largely within the control of the Welder. Most welding voltages are not high enough to cause severe injury by electric shock; however, a mild shock from normal working voltages may cause involuntary muscular action that might cause a person to lose balance. Wet clothing reduces the resistance of cloth and increases the effect of a normally small shock. Under these conditions, the voltages produced by an electric welder can be dangerous to one's life. Avoid standing in water, on wet surfaces, or working with wet hands, gloves, or garments.

3.8.4 Don’t touch or allow live metal parts of an electrode holder to touch bare skin or wet clothing. Do not replace the welding electrode with bare hands or with a wet welding glove. Don’t permit an electrode holder to touch any metal that contacts the welding ground. This will cause a dead short circuit on the welding generator, resulting in damage to the equipment.

3.8.5 Understand the following issues as they relate to signalized track:

a) High amperage current (100 to 300 amperes) used for welder operation, which flows through a section of rail during the arc welding process, tends to leak to earth and unbalance the track circuit;

b) Stray electrical current could damage sensitive signal equipment that is used for train operation and active grade crossing warning devices;

c) Unbalancing of the track circuit may affect the operation of track relays, resulting in signal interruptions;

d) Sufficient stray current could flow through the track relay to hold it energized with the track circuit occupied if the return current of the welding outfit is allowed to flow through only a short section of rail; and

e) Operation of the electric arc welder on bridge guard rails or non-bonded tracks, such as sidings or non-signalled running tracks, running parallel to or in close proximity to main tracks equipped with track circuits, will also affect the proper operation of the track circuit. The following instructions must be followed when using electric arc welding equipment on any track or guard rail in track-circuited territory:

   i. Before proceeding with the use of an electric welder on tracks in track-circuited territory, the Signals & Communications (S&C herein) Maintainer must be notified a sufficient time in advance to install circuit fuses to protect signal equipment; and

   ii. The location of insulated joints must be ascertained before any work is undertaken. If there is a question as to the limits of any track circuit, a signal employee must identify the limits prior to the start of work.

3.8.6 Electric arc welders (generators) must be properly insulated, and insulation kept in good condition:

a) All electrical equipment must be grounded at the source, and all connections must be clean and tight;

b) The work/ground clamp must be clean, fit well, and make full contact without any current resistance. It must be placed as close as possible to the area being welded; and

c) Work/ground clamps must never be clamped on any frog bolt, track bolt, or to the base of the rail.

3.8.7 Do not disturb the work/ground clamp while welding. Welders equipped with mechanical ground bars must not be moved during welding nor stopped with the ground spanning an insulated joint.

3.8.8 Don't allow the ground plates to touch the opposite rail of the track on which welding is performed, as this will cause severe damage to signal apparatus:

a) Use caution while working on frogs with gauge plate(s) between the guard rail and frog. Do not allow the electrode holder or wire feeder gun to come in contact with the opposite side of the gauge plate from the grounded work area.

3.8.9 Never drop the welding electrode and ground plates in the ballast or allow them to come in contact with the ground while the generator is running. Carefully lay them on the end of a tie when the welder is not in operation.

3.8.10 Heat in cables/connections is resistance to current, which generates heat. If heat is felt on the cable or cable connections, inspect for the following causes:

a) Loose connections;

b) Cables coiled on reel or hooks/hangers;

c) Broken/damaged wire or cable;

d) Corrosion on connections;

e) Overloading cables beyond rated capacity for amperage and distance.

3.8.11 Use additional protection of the insulation at points where the wires/cables are run under or over the rails of any track by:

a) Sliding a short section of rubber hose; or

b) Placing an insulating mat between the wire and rail.

3.8.12 When performing electric arc welding operations on or about bridge structures, never use guard rails or bridge members for completing the "Hot" side of the circuit between the generator and welding electrode. Use an insulated cable conductor for this purpose. Exercise care when welding guard rails or bridge members to prevent tools, tie plates, or other metallic objects from making contact between the main track rails and the member on which welding is performed.

3.8.13 Ensure equipment such as grinders, slotters, push cars, and hi-rail vehicles are appropriately insulated to prevent shorting the track circuit.

a) Never use multiple operator welding systems, where two or more welding circuits are connected electrically to the same source in track circuit territory,

b) Use no more than two single arc welding machines within the limits of any track circuit. This applies to territory having one or multiple tracks; and

c) Ensure that automatic and semi-automatic wire feed systems are fully insulated from the unit frame.

3.8.14 When welding on conventional insulated joints, apply joint bars on only one joint at a time.

Note: When the insulated joint is on a closure rail, the installation of joint bars may short the track circuit.

a) Protect bond wires during preheating, post-heating, welding heat, surface grinding, and cross-slotting.

b) Ensure that the polarity switch is in the “OFF” position while travelling or when removing the welding machine from the track. Some welding machines do not have a polarity switch with an “OFF” position. Ensure that these welding units are turned off while travelling or when removing the machine from the track.

c) Electric current flowing through any conductor causes localized Electric and Magnetic Fields (EMF). Welding current creates EMF fields around welding cables and welding machines.

d) EMF fields may interfere with some pacemakers, and Welders having a pacemaker should consult their physician before welding.

e) Exposure to EMF fields in welding may have other health effects which are currently not known.

f) Do not place your body between the electrode and work cables. If the electrode cable is on your right side, the work/ground cable should also be on your right side.

g) Connect the work/ground cable to the workpiece as close as possible to the area being welded.

h) Ensure cables are not damaged, cut, or pinched. Protect cables from vehicular traffic or other hazards.

i) Place the welding transformer in close vicinity to the work, such that it can be switched off quickly in case of emergency to cut off the power source.

j) Turn off the welding transformer during breaks or when not in use. Detach the remaining welding electrode on the electrode holder before leaving the welding area.

3.9 Grinding Equipment: Abrasive Wheels and Stones

3.9.1 All Welders must be trained in the safe operation of the grinding equipment, machines, and tools assigned to them:

a) Welders must be aware of minor troubleshooting remedies; and

b) Prior to initial use, the operator must make daily checks and inspections of all fluid levels and maintenance requirements following the manufacturer's instructions.

3.9.2 Use a spark shield/guard whenever grinding, slotting, or cutting.

3.9.3 Keep flammable materials away from work area. Never fuel or refuel in your Hot Work area. Move your equipment away from the immediate work area and allow engine to cool prior to fueling or refueling.

3.9.4 Inspect all gasoline or hydraulic grinding equipment prior to use.

3.9.5 Ensure they are leak-free prior to use.

3.9.6 Ensure that all electric or high-frequency grinding equipment is properly grounded.

3.9.7 Ensure that all grinding stone/wheel guards are in place and properly adjusted for protection. Ensure that guards are not removed or altered.

3.9.8 Ensure that all grinding, slotting, and cutting stones, wheels, or blades are appropriately stored and protected from damage, moisture, vibration, and cracking.

3.9.9 The operators must ensure that the expiration dates are not exceeded, for all grinding, slotting, and cutting stones, wheels, or blades.

a) The expiration date is two (2) years from the manufacture date.

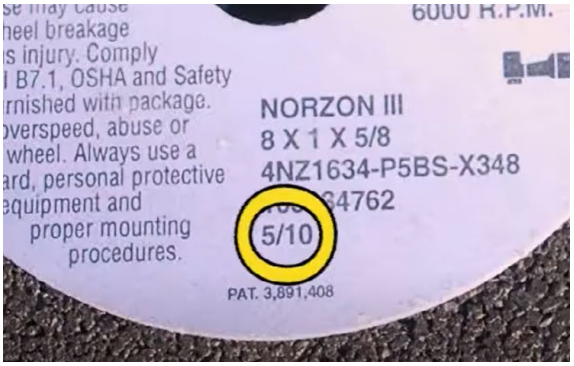


Figure 3-3: Manufacture date
Courtesy Norton

b) Ensure that the machine or tool's operating speed RPM never exceeds the maximum RPM speed rating of the grinding, slotting, and cutting stones, wheels, or blades.

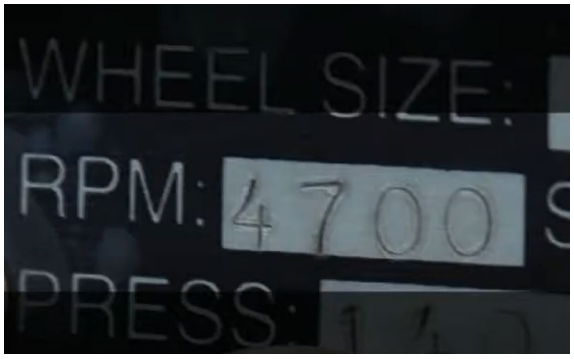


Figure 3-4: Tool RPM rating
Courtesy Norton

3.9.10 Visually inspect, prior to each use, every stone, wheel, or blade, whether new or used, looking for:

a) Cracks;

b) Large nicks;

c) Water damage; and

d) Other imperfections.

3.9.11 Daily and prior to initial use of all grinding, slotting, or cutting stones or wheels, they must be allowed to run at operating speed for one (1) full minute prior to grinding, slotting, or cutting operations.

3.9.12 Make gradual contact with the work area to allow the cold stone, wheel, or blade to warm up.

3.9.13 Though most stones, wheels, and blades are fibre-bound, they may break under excessive side pressure. Be aware of this and use extreme caution. Do not force stones, wheels, or blades.

3.10 Workplace Hazardous Materials Information System (WHMIS)

3.10.1 Ensure that a hazardous material is not used, handled, or stored at a workplace unless the prescribed requirements concerning identification, material safety data sheets, decanting and worker instruction and training are met.

3.10.2 Ensure that all hazardous materials present in the workplace have been identified in the prescribed manner.

3.10.3 Obtain and prepare a current material safety data sheet for all hazardous materials present in the workplace.

3.10.4 Ensure that the required identification is available in both English and French and such other languages as may be prescribed.

4 Training and Certification

4.1 Track Welder Certifications

4.1.1 All Welders performing work for Metrolinx must be trained and certified to weld on rail and rail components. Welders will only be allowed to weld on the rail or rail component using the process for which they hold a valid certification.

4.1.2 This certification will involve:

a) Demonstrating safe handling and operation of:

b) Oxygen/fuel gas cutting and heating equipment;

c) Air carbon arc cutting and gouging equipment;

d) Rail puller/expander (120 ton);

e) Electric welding power source, wire feeder, and welding accessories;

f) Grinding equipment;

g) Demonstrating the ability to follow and adhere to a Welding Procedure Specification (WPS) for:

i. Thermite welding;

ii. Electric flash butt welding; and

iii. Electric-arc methods of welding FCAW and/or SMAW.

4.1.3 Each Welder must be certified by one or more of the following:

a) A railway track welding instructor or facility;

b) A representative from a thermite weld supplier;

c) A representative from an electric flash butt welding company; or

d) An instructor from the Canadian Welding Bureau (CWB) or American Welding Society (AWS) using AWS specification D15.2 for *Joining Railroad Rail and Related Rail Components*.

4.1.4 It is the welding contractor's responsibility to maintain the records of each Welder. Metrolinx may request the Welder Qualification Records (WQR) documentation to identify the Welding Procedure Specification (WPS) used for each type of certification. The record must indicate:

a) One or more of the following WPS or category(s) for which an individual is certified:

i. Welding of carbon steel rail by: FCAW (wire) and SMAW (stick electrode);

ii. Welding of carbon steel rail by thermite welding with the Pandrol and Orgo-Thermit welding processes;

iii. Welding of carbon steel rail by Electric Flash Butt (EFB) welding;

iv. Welding of austenitic manganese steel by FCAW (wire) and SMAW (stick electrode);

v. The date each WPS certification was granted; and

vi. The person and/or training facility who certified the individual Welder.

b) New Welders must get certified (where possible) upon hiring.

c) Rehired Welders whose certifications are more than 1 year from the date of rehire must be recertified.

d) All Welders must recertify once every three years for each specific WPS.

4.1.5 The certification test will consist of actual welding, finish grinding to tolerances, as well as a written or oral examination on safety precautions and welding procedures. The test will be specified by:

a) **Certification by standard test.** This certification requires completion of a standard test weldment in accordance with a certified WPS, evaluation of the test weldment according to the method used, and acceptance of the weldment in accordance with the criteria of the process;

b) **Certification by workmanship test.** This certification requires completion of a Workmanship Test, welded in accordance with a certified WPS, which addresses typical production joints and conditions. Workmanship weldments are accepted or rejected primarily on the basis of the visual examination criteria. Other tests or examinations (macro-examination, etc.) may be specified by the CWB or the AWS;

c) Every 2 years, anyone supervising welding operations, working as a Track Welder, Welder Assistant, or Welder Helper for Metrolinx must pass a written exam on Metrolinx Welding Manual procedures and policies. A minimum score of eighty-five percent (85%) must be achieved.

4.1.6 Metrolinx reserves the right to accept or reject the WQR for any WPS.

4.1.7 No person will perform any welding without being trained and certified.

Exception: Persons in training to become Welders may perform work specified by a Welding Instructor or Manager, while welding under the direct supervision of a trained and certified Welder.

4.2 Knowledge and Understanding of Rules

4.2.1 Track welders must be examined and certified according to the following list of rules, regulations, and standards:

a) Welders must have and maintain a current copy and updates of the Metrolinx Welding Manual;

b) Welders must have and maintain a current copy and updates of Metrolinx *Canadian Rail Operating Rules* (CROR);

c) Welders must have and maintain a current copy and updates of the Metrolinx Track Standards.

d) Welders must have and maintain a current copy and updates of Metrolinx *General Engineering Instructions* (GEI);

e) Welders must have and maintain a current copy and updates of Transport *Canada Rules Respecting Track Safety*;

f) Welders must have and maintain a valid Commercial Driver's License, with the ability to safely transport welding materials of the trade.

g) Welders must have and maintain training on Transport Canada, *Workplace Hazardous Materials Information System* (WHMIS), Propane Storage and Handling Code (CAN/CSA-B149.2);

h) Welders must be trained for safe hi-rail operations.

i) Welders must be trained for the safe crane or lifting boom operations, if a welding truck is so equipped;

j) Welders must be trained for Fall Protection procedures;

k) Welders must have and maintain training on the combined Fire Hazard Reduction Plan and the Fire Preparedness and Communication Plan; and

l) Welders must be able and trained to wear a respirator while welding, grinding or carbon arc air gouging or cutting on manganese track components.

4.2.2 Welders and contractors are responsible for keeping current and maintaining records of all Metrolinx required training.

4.2.3 All Welders working on Metrolinx-owned property must have available current copies of training records.

4.2.4 Training records must be available for review upon request by Metrolinx officers.

5 Equipment Use, Maintenance and Inspections

5.1 General

5.1.1 Any new tools or processes must be approved by the Director, Engineering – Track prior to implementation.

5.1.2 All Welders must be trained in the safe operation of the equipment, machines, and tools assigned to them. They must be aware of minor troubleshooting remedies. Prior to initial use, the operator must perform daily checks and inspections of all fluid levels and maintenance requirements following the manufacturer's instructions.

5.1.3 Prior to use, tools or equipment must be inspected. If found to be defective, the tools must be repaired or adjusted for safe operation.

5.1.4 If field repairs or adjustments do not correct the defective condition, then the defective tool or equipment must be removed from service, tagged, or marked defective and reported to the employee's immediate supervisor.

5.2 Electric Welding Equipment

5.2.1 All electric welding power sources must be capable of producing a minimum of 400-amp Direct Current (DC), Constant Current (CC), and Constant Voltage (CV), DC Electrode Positive (DCEP) and DC Electrode Negative (DCEN) current of output, for a distance of 150 ft (46 m) with a 100% duty cycle. Electric welding power sources must also be capable of supplying 120-amp and 220-amp Alternating Current (AC) electrical power.

5.2.2 All wire feeders must be capable of input power of 14-48 volts DC, 110 max output constant voltage. Input welding circuit welding rating of 450 amps at 60% duty cycle. Ability to run up to 5/64 in (2 mm) flux-cored wire, and up to 45 lb (20.4 kg) spool of wire.

5.2.3 It is mandatory to use a wire feeder. Any welding repair to frogs, crossing diamonds, engine burns, rail ends, etc., that require more than a 30-minute repair (minor repair) will be done with Flux Cored Arc Welding (FCAW) wire feeder. All welding crews, other than a dedicated thermite welding crew, must have and be trained and certified to weld with the FCAW wire feeder and are required to use it.

5.2.4 Shielded Metal Arc Welding (SMAW) stick electrode weld is only allowed for minor repair work, less than 30 minutes of welding work, or if the wire feeder is inoperative. Welders must be trained and certified to weld with the SMAW process.

5.2.5 Electric track welding crews must have an air compressor with a minimum of 30 CFM (0.85 CMM) and the ability to adjust from 4 psi to 120 psi (28 to 827 kPa). This can be built into the welding power source or a stand-alone unit. These are to be used:

a) To control cooling of manganese castings;

b) For air carbon arc cutting or gouging;

c) For needle scalers, chippers, and other air tools; and

d) At times, in the thermite welding preheating operation.

5.2.6 The jaws of the electrode holder must be kept clean.

5.2.7 Welding cables:

a) Cable capacity must be matched to the welding machine;

b) The recommended normal length of cables connected to the welding machine is 50 ft (15 m). Shorter or longer lengths may be used with the adequate size cable to carry the required load the distance of the additional length;

Table 5-1: Cable Sizing According to Load and Distance

Amperes	Percent Duty Cycle	Cable Sizes for Combined Lengths of Electrode and Work Cables - Rubber Covered Copper Rated 167°F (75°C)				
		0 to 50 ft	50 to 100 ft	100 to 150 ft	150 to 200 ft	200 to 250 ft
200	60	2	2	2	1	1/0
200	100	2	2	2	1	1/0
250	30	3	3	2	1	1/0
250	40	2	2	1	1	1/0
250	60	1	1	1	1	1/0
250	100	1	1	1	1	1/0
300	60	1	1	1	1/0	2/0
300	100	2/0	2/0	2/0	2/0	3/0
350	40	1/0	1/0	2/0	2/0	3/0
400	60	2/0	2/0	2/0	3/0	4/0
400	100	3/0	3/0	3/0	3/0	4/0
500	60	2/0	2/0	3/0	3/0	4/0
600	60	3/0	3/0	3/0	4/0	2-3/0
600	80	2-1/0	2-1/0	2-1/0	2-2/0	2-3/0
600	100	2-1/0	2-1/0	2-1/0	2-2/0	2-3/0
Tabled values are for operation at ambient temperatures 104°F (40°C) and below. Applications above 104°F (40°C) may require cables larger than recommended or cables rated higher than 167°F (75°C).						

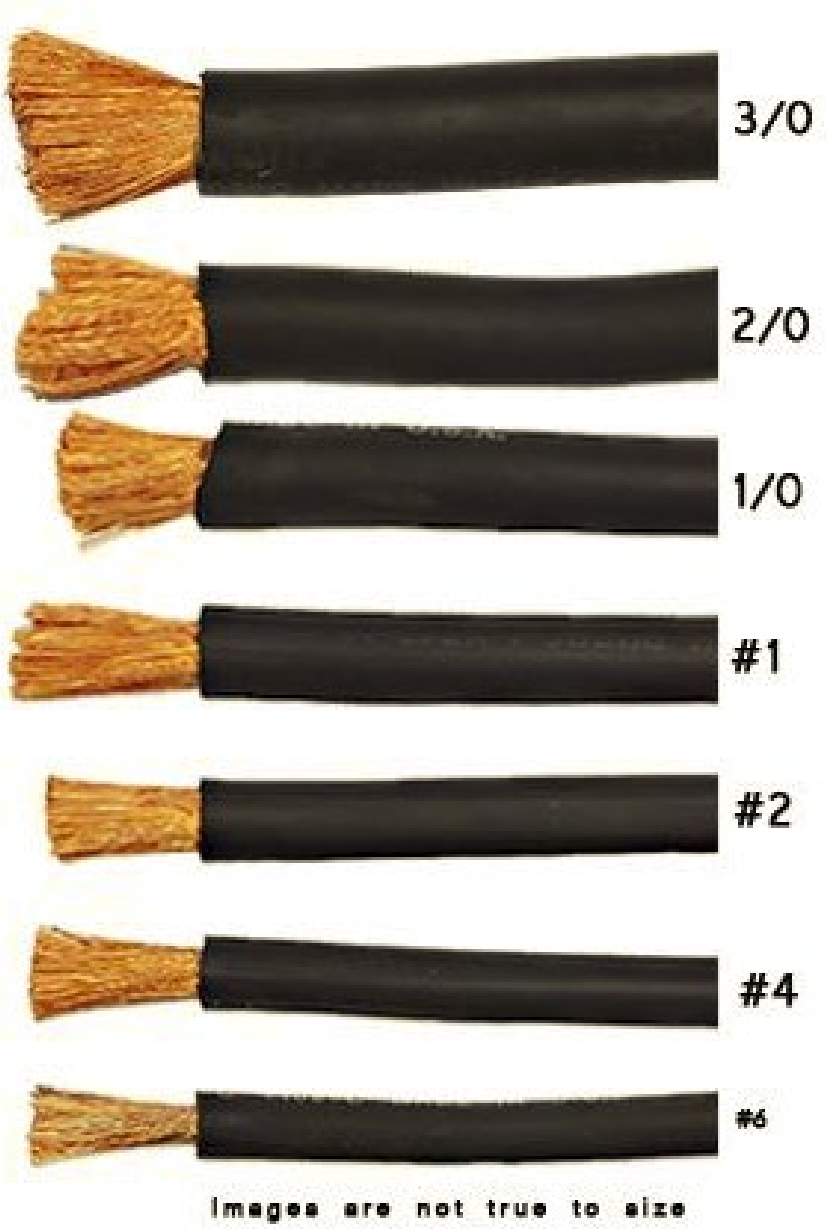


Figure 5-1: Comparison of Cable Sizes

c) Where track access is limited by terrain, an additional 50 ft (15 m) of cable may be added using insulated cable connectors.

Figure 5-2: Typical Cable Connectors

5.2.8 Ensure all cables are in good condition and connections are tight.

a) The female cable connector must always be on the power source receiving end of the cable.

5.2.9 Cable splices must be 10 ft (3 m) or greater from the wire feeder or electrode holder.

5.2.10 Uncoil cables before welding. They should be strung out on the ground without crossing themselves. Do not leave cables coiled up and hanging from a hook or coiled up one layer upon another while welding.

5.2.11 Do not coil or loop electrode cables around the body while welding.

5.2.12 Ensure that all ground connections are mechanically strong, close to the work, and of adequate size electrically.

5.2.13 Never attach a work/ground clamp to a frog bolt, track bolt, or to the rail base. The use of a work/ground clamp that attaches to the head of the rail is recommended.

5.2.14 All SMAW electrode holders must be of the proper size to match the cable size and amperage loads required.

5.2.15 All work/ground clamps must be of the proper size to match the cable size and amperage loads required.

5.2.16 Never operate a gasoline or diesel-powered welder in a confined space or without adequate ventilation.

5.2.17 **Safety critical rule:** Never strike an arc on or touch an electrode against oxygen, propane, or other cylinders (tanks) used for the storage of compressed gas.

5.2.18 Electrodes must be removed from holders when not in use. Electrode stubs should be disposed of in a metal container.

5.2.19 Only trained and certified individuals or vendors will make repairs to welding machines.

5.2.20 Where practical, enclose the work with a fireproof screen to protect the eyes of others from the glare of welding rays. Welders working along the line of a road must take precautions to protect the public and other employees not involved in the welding process from glare or arc flash.

Figure 5-3: Examples of Screens Used to Reduce Glare

5.2.21 When the use of a wire feeder is complete, the welding gun cable and wire roll must be removed from the feeder, and properly stored for transport.

5.3 Rail Puller/Expander

A rail puller-expander is a device used to overcome the extreme contraction or expansion forces due to the effects of temperature present in continuous welded rail. It is designed with a hydraulic system capable of holding rail end gaps for long periods of time such as is required during the performance of thermite welding operation. Rail puller-expanders have other uses, such as in the repair of rail breaks and pull-aparts, the destressing of CWR, and the installation of insulated joints. The primary use of a rail puller-expander by a Welder is to maintain precise rail end gaps during the welding operation and cooling-off period.

5.3.1 All welding crews that perform thermite welding must have, maintained in good working order, a minimum capacity 120-ton hydraulic rail puller for use when and where required;

5.3.2 Check the rail puller to ensure it has a safety brake system in proper working order to prevent accidental slippage while under load;

5.3.3 Only those persons who have been trained and certified can operate a rail puller; and

5.3.4 Follow and understand all the manufacturer's instructions for the safe operation of the type of puller being used;

5.3.5 Use proper crane handling and lifting procedures when unloading and placing on the rail:

a) Handling suspended loads requires the use of a tagline;

b) Never stand under a suspended load;

5.3.6 Inspect all components of the rail puller and related equipment before each use/pull. If any parts are worn, damaged, or defective, replace them prior to use;

5.3.7 Inspect the rail to be pulled for potential snags. For example, thermite welds, field flash butt welds and anchors not removed can catch on tie plates and pull up ties. The subsequent sudden release of tension on the rail expanders/pullers may cause wedges or other heavy parts to fly off, resulting in serious injury.

5.3.8 Inspect the rail web where clamps will contact the web.

5.3.9 Thoroughly clean the rail web of oil, grease, or dirt with a non-lubricating solvent (such as those used to clean brake surfaces) or use a soft torch flame. Then, wire brush. Grind the area clean if needed. Do not use lubricating solvents, such as WD40 or similar products, to clean the rail.

5.3.10 Remove all mill scale from the clamping area. Using a soft torch flame, clean and wire brush. Grind the area clean if needed.

5.3.11 Do not clamp on rail branding (raised lettering). If unavoidable, grind off the branding on the web. Care must be taken not to over-grind or "blue" (overheat) the rail.

5.3.12 Clean the rail clamp teeth with a wire brush and inspect prior to each use.

5.3.13 Be aware of the rail puller Red Zone during the pull and while the puller is under load. The Red Zone is defined as 15 ft (4.6 m) along the rail from each end of the puller and along the length of the puller.

5.3.14 Ensure that all employees stand away from the puller when pulling. Only the operator is allowed to stand alongside the puller.

5.3.15 Watch the puller gauge to ensure the unit does not exceed the design capacity (in tons) of the puller when pulling.

5.3.16 Release the rail puller tension if the rail is pulling hard, and pull the rail up again. Remove additional anchors or heat the rail, if required.

5.3.17 Do not remove or apply anchors while the rail puller is pulling.

5.3.18 Do not strike any portion of the rail puller or the rail while the puller is pulling. Only tap the tie plates to permit the longitudinal force to equalize over the unanchored rail. Do not tap tie plates located within the Red Zone. On concrete tie areas, tapping the web of the rail is permitted, but not within the Red Zone and only with a brass hammer.

5.3.19 Lock the puller and close the pressure valve after pulling is completed and the proper rail gap has been achieved. Follow all of the manufacturer's instructions for the type of puller being used. Generally, this will consist of:

a) Turning the hydraulics off;

b) Moving the directional valve back and forth to relieve trapped pressure;

c) Checking the pressure gauge to make sure it is at zero; then

d) Commence normal work applications.

5.3.20 Do not apply anchors within the Red Zone.

5.3.21 Proceed with the desired work application. Stay alert and attentive to the surroundings.

5.3.22 Use alignment plates, "A" frames, or alignment jacks, for setting and adjusting the rail crown and alignment when thermite welding:

a) The use of wedges is not allowed. The use of or hitting rail alignment wedges may cause the rail puller to slip;

b) Keep clear of all pinch points.

5.3.23 Stand or kneel to the outside of the puller while working. Never place your feet between the rail and the inside of the puller.

5.3.24 When using the rail puller for all closure welds or when making consecutive welds on a plug rail, the second weld (closure weld) cannot be pulled until the first weld has cooled below 700 °F (371 °C).

5.3.25 Allow the weld to cool below 700 °F (371 °C), then remove the puller from the rail, following the manufacturer's instructions for the type of puller being used.

5.3.26 Inspect, clean, and lubricate the puller as recommended.

5.3.27 Load and store in a safe and secure manner. (Use a tagline.)

5.4 Electric Arc Welding Equipment and Hardware

5.4.1 Welders performing electric arc welding must be equipped with the following in the quantity prescribed:

Table 5-2: Required Equipment and Hardware for Electric Arc Welding.

Item	No. Needed
Electric welding power sources must be capable of producing a minimum of 400-amp direct current (DC) constant current (CC) and constant voltage (CV) DC electrode positive (DCEP) and DC electrode negative (DCEN) current of output, to a distance of 150 ft (46 m) with a 100% duty cycle. Must also have AC 120-amp and 220-amp electrical power supplies.	1
Air compressor with a minimum of 30 CFM (0.85 CMM) and ability to adjust from 4 psi to 120 psi (28 to 827 kPa).	1
Welding cable, 100 ft (30 m) minimum length, dual with quick lock insulated connectors. Cable load capacity must be matched to the welding machine.	2
Wire feeder with gun, 10 ft (3 m) cable power lead with quick lock insulated cable connector and liner, drive rolls for 5/64 in (2 mm) flux core diameter wire, nozzle insulators.	1
Spares of each: liner, drive rolls for 5/64 in (2 mm) flux core diameter wire, nozzle insulators.	1 of each
Wire cutting pliers for trimming welding wire.	1
Welding helmet auto darkening or fixed lens.	1 plus 1 spare
Grinding cutting face shields clear and a No. 5 shade lens.	1 of each
Proper fire protective clothing for welding, cutting, and grinding. Including but not limited to: gloves, jackets, aprons, and leggings.	1 per person on crew
First aid kit with burn kit supplies appropriate for size of crew.	1
Spare lens (No.10 – No.13) and batteries if auto-darkening.	2
Respirator or fresh filtered air welding helmet.	1
Spare filters/batteries for respirator.	1

Item	No. Needed
Electrode holder/stringer with 10 ft (3 m) cable power lead with quick lock insulated connector (400-amp minimum or to match size of power source).	1 plus 1 spare
Work/Ground clamp (500-amp minimum) with "C" clamp positive lock or magnetic.	1
Quick lock insulated cable connector male/female spare set.	1
Air carbon arc torch with insulated boot and quick lock insulated cable connector (500-amp minimum).	1
Spark shield for fire and arc flash protection.	1
Water tank (35 gallon/132.5 litre minimum) with pump spray nozzle and 25 ft (7.6 m) minimum length of hose.	1
10 lb (4.5 k) ABC fire extinguisher in addition to what is required in truck.	1
Hand pump water cans (5 gallon/18.9 litre minimum) 1 for each person on crew.	2
Air needle scaler.	1
Chipping hammer.	1
Wire brush.	1
Ball peen hammer (2 lb/.9 k).	1
36, 18 and 12 in (914, 457 and 305 mm) straight edges (Starrett Precision recommended).	1 each
Taper gauge (.010 - .150) (Starrett Precision recommended).	1
25 ft x 1 in (7.6 m x 25 mm) tape measure.	1
Frog flangeway check gauge.	1
Conformal frog gauge set.	1 set
Flange guide carbon blocks (24 x 2 x 1 13/16 in) (609 x 50 x 46 mm).	2
Radius gauge set (½ in R, 9/16 in R, 5/8 in R, ¾ in R) (127 mm R, 14 mm R, 15 mm R, 19 mm R).	1 set

Item	No. Needed
Infrared thermometer (temp gun range of -40 to 1600 °F/-40 to 871 °C) or temperature indicating sticks (Tempilstik) of various temperatures: 1 each of 350 °F, 400 °F, 450 °F, 500 °F, 600 °F, 700 °F, 900 °F, 1100 °F, 1200 °F (176 °C, 204 °C, 232 °C, 260 °C, 315 °C, 371 °C, 482 °C, 593 °C, 648 °C).	1 or various of each
Oxygen/propane torch set, with cutting, preheating attachments and Flashback arrestors (minimum 50 ft (15 m) length of 3/8 in (9 mm) diameter "T" grade twin hose), including supply tanks. Smith, Victor, and Harris are approved.	1
Air-powered smoke cannon or exhaust fan.	1
Addition to truck mounted, portable work light for night work away from truck with cords or batteries to power.	1 or various of each
Various grinders to prep, clean, finish profile, and slot all railway track components, such as frogs, diamond crossings, switch points, stock rails, plates, clips, etc. These can be electric, hydraulic, gas, or battery-operated.	1 or various of each
Toolbox with various hand tools to make adjustments, minor repairs, and changing consumables, including but not limited to wrenches, socket sets, pliers, screwdrivers, allen wrenches, adjustable wrenches, hammers, etc.	1 or various of each
Various railway track hand tools. Including but not limited to: track jack, various track wrenches or sockets for frog and track bolts, claw bar or spike puller, spike maul, sledgehammer, tamping bar or tool, etc. These tools can be hand, electric, hydraulic, gas, or battery-operated.	1 or various of each

5.5 Thermite Welding Equipment and Hardware

5.5.1 All Welders performing thermite welding must be equipped with the following in the quantity prescribed:

Table 5-3: Required Equipment and Hardware for Thermite Welding.

Item	No. Needed
120-ton hydraulic rail puller, including power source to operate. This can be truck-mounted or a stand-alone unit.	1
Weld preheating system. This can be oxygen/propane or air/propane.	1
If the air/propane process is used, it can be run off welding power source, stand-alone compressor, hydraulic, under hood motor driven air pump, gas, or battery-operated compressor meeting a minimum of 30 CFM (0.85 CMM). With a minimum of ¾ in (19 mm) diameter hose 50 ft (15 m) in length and air preheat burner with pressure adjustments for flow of air and propane.	1
Oxygen/propane torch set, with cutting, preheating attachments and flashback arrestors, minimum 50 ft (15 m) of 3/8 in (9.5 mm) diameter "T" grade twin hose, including supply tanks. Smith, Victor, and Harris are approved.	1 set
If oxygen/propane preheating process is used in addition to the minimum 50 ft (15 m) of 3/8 in (9.5 mm) "T" grade twin hose, in-line flashback arrestors, and in-line pressure gauges. Torch body can NOT have built-in flash arrestors. Preheating torch head (2 rows of 11 orifices totaling 22), Smith, Victor, or Harris are approved.	Set of each
Torch stand for the type of preheating torch being used.	1
Dye penetrant testing kit (cleaner, dye, developer) with a supply of clean rags.	1
Infrared thermometer (temp. gun range of -40 to 1600°F/-40 to 871°C) or temperature indicating sticks (Tempilstik) of various temperatures: 1 each of: 400 °F, 450 °F, 600 °F, 900 °F, 1100 °F (204 °C, 232 °C, 315 °C, 482 °C, 593 °C).	1 or various of each
Must have a 450°F temperature indicating stick (Tempilstik).	1

Item	No. Needed
36 in (914 mm) straight edge (Starrett Precision recommended).	1
36 in (914 mm) magnetic adjustable straight edge.	1
Taper gauge (0.010 – 0.150 in /0.25 – 3.81 mm) (Starrett Precision recommended).	1
Railhead Wear Gauge(s) Metric (112 to 141 lb rail).	1
25 ft x 1 in (7.6 m x 25 mm) tape measure.	1
Carbide mould file.	1
Rail aligners can be plates, “A” frame, or jacks.	2 sets
Track jacks can be hand, hydraulic, air, or battery/electric.	2 each
Rail saw can be hydraulic, gas, or battery/electric.	1
Rail drill can be hydraulic, gas, or battery/electric.	1
Weld shear must have a minimum of 5 ½ in (140 mm) stroke. Can be hand pump, hydraulic, gas, or electric / battery operated.	
Various grinders, rail profile grinder, straight stone 1 x 8 in (25 x 203 mm), multipurpose web and head wash, to prep, clean, and finish profile rail head. These can be electric, hydraulic, gas, or battery-operated.	1 or various of each.
Fireproof slag and waste disposal barrel or dump box.	1
Various railway track hand tools, including but not limited to: track jack, various track wrenches or sockets for frog and track bolts, claw bar or spike puller, spike maul, spike lifter, sledgehammer, tamping bar or tool, etc. These tools can be hand, electric, hydraulic, gas, or battery-operated.	1 or various of each
Hot cut chisel.	1
Shovels.	2
Paint stick marking pens.	2
Stopwatch.	1

Item	No. Needed
Tie plug applicator gun.	1
Tie plugging compound or tie plugs.	1
Welding umbrella/tent for inclement weather.	1
Spark shield for fire protection.	1
Water tank (35 gallon/18.9-litre minimum) with pump spray nozzle and 25 ft (7.6 m) minimum of hose.	1
10 lb (4.5 k) ABC fire extinguisher in addition to what is required in truck.	1
Hand pump water cans (5-gallon (18.9 litre) minimum)) 1 for each person on crew.	1 per person on crew
Proper fire protective clothing for welding, cutting, and grinding, including but not limited to gloves, jackets, aprons, and leggings.	1 per person on crew
First aid kit with burn kit supplies appropriate for size of crew.	1
Grinding cutting face shields clear and a No. 5 shade lens.	1 of each per crew member
Respirator is recommended, but not required, for Thermite Welding or grinding/ cutting rail.	1
Spare filters/batteries for respirator.	1
Toolbox with various hand tools to make adjustments, minor repairs, and changing consumables, including but not limited to wrenches, socket set, pliers, screwdrivers, allen wrenches, adjustable wrenches, hammer, etc.	1 or various of each

Table 5-4: Required Hardware for Pandrol Thermite Welding

Hardware specific to Pandrol Thermite Welding Process **Item**	No. Needed
Straight base plate 107 - 141 lb (48.5 – 63.9 k). *Note:* A smaller rail requires a different base plate.	2
Comp base plate.	2
Mould jackets 107 - 141 lb (48.5 – 63.9 k). *Note:* A smaller rail requires a different mould jacket.	2 sets
Head wash mould jackets. *Note:* no base plate is required.	1 set
Mould clamp.	1
Weld demoulding tool.	1
Crucible removal fork.	1
Slag drip pan.	1
Torch stand.	1

Table 5-5: Required Hardware for Orgo-Thermit Welding Process

Hardware specific to Orgo-Thermit welding 2-piece mould process **Item**	No. Needed
Mould shoes (2 pieces). *Note:* smaller rail requires different shoes.	1 set with 2 pieces
Mould clamp.	1
Slag drip pans (2 pieces).	1 set with 2 pieces
Crucible removal fork.	1
Standard demoulding tool.	1
Torch stand.	1
Torch burner saddle.	1

5.6 Grinding Equipment

5.6.1 All Welders must be trained and certified in the safe operation of the grinding, cutting, or slotting equipment, machines, and tools assigned to them:

a) Welders must be aware of minor troubleshooting remedies; and

b) Prior to initial use, the operator must make daily checks and inspections of all fluid levels and maintenance requirements, following the manufacturer's instructions.

5.6.2 Ensure all grinding stone/wheel guards are in place and properly adjusted for protection. Guards must not be removed or altered.

5.6.3 The machine or tool's operating speed RPM must never exceed the maximum RPM rating of the grinding, slotting, and cutting stones, wheels, or blades.

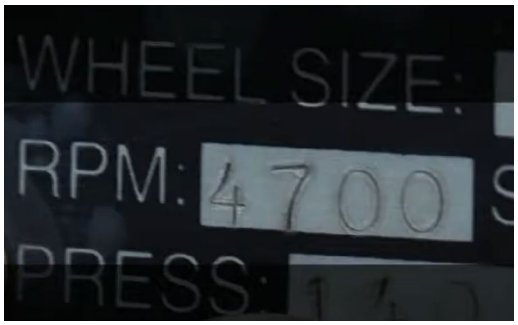


Figure 5-4: Tag with Equipment RPM Rating
Courtesy Norton

5.6.4 There are various manufacturers and types of equipment that railway track Welders use for grinding, cutting, and slotting, along with various types of power sources. Some equipment is specific only to the job or task. Some examples are:

a) **Handheld grinders**: Commonly known as 8 x 1, this is a general-purpose grinder:

Figure 5-5: Electric Handheld Grinder (b) Hydraulic Handheld Grinder
Courtesy CN Training

i. Used for numerous jobs: hand profile/shaping corner radii; grinding and cleaning out weld repair areas in rail, frogs, diamond crossings, etc.;

ii. Can also be adapted to use slotting stones 8 x 3/16 x 5/8 in (203 x 4.7 x 15 mm) and 8 x 1/8 x 5/8 in (203 x 3 x 15 mm):

iii. Slotting stones also vary in diameter as 4, 6, and 8 in (101, 152, and 203 mm), which can be adapted to disk grinders, electric or battery powered.

b) **Switch grinders:** Gas-operated (MC-2 and MC-3) are the most popular because no cord or hoses is attached while working on turnouts:

Figure 5-6: Switch Grinders
Courtesy IRS, Pinterest, and CN Training

i. Used for grinding metal overflow from switch points, stock rails, frogs, and guard rails. Can also be used for surfacing frogs and shaping angles on Sampson switch points and undercut stock rails;

ii. Uses a special grinding stone 10 x 1 ¼ x 1 in (254 x 31 x 25 mm).

Figure 5-7: S&C Grinding Stone
Courtesy Norton Abrasives

c) **Precision frog grinder:** Used for surface finish grinding of frogs and diamond crossings, it has different adaptable work heads and adjustable angles for grinding conformal frog 1:20 slope angles.

Figure 5-8: Precision Frog Grinders
Courtesy Pandrol and CN Training

d) **Rail weld profile grinder**: Used for rail surfacing or matching rail profiles and radii:

Figure 5-9: (a) and (c) Pandrol/Matweld Profile Grinder, (b) Stanley Profile Grinder
Courtesy Pandrol, Stanley, and CN Training

i. Primarily used for thermite welds, electric flash butt welds, engine burn welds, rail ends and joint repair welds.

e) **Web utility grinder:** Commonly known as a bicycle or Harley grinder:

Figure 5-10: Web Utility Grinder
Courtesy Pandrol and CN Training

i. Primarily used for thermite and electric flash butt welds.

f) **Handheld surface grinder:** Used for hand surfacing frogs and diamond crossings.

Figure 5-11: Handheld Surface Grinder
Courtesy Industry Railway Suppliers

g) **Handheld disk grinders**: Made by numerous manufacturers, power sources, supplies, and sizes to adapt to various applications.

h) **Bull nose grinder**; used for chamfering bolt holes. Adapter for 1 in (25 mm) drive impact wrench.

Figure 5-12: Bull Nose Grinder Adapter
Courtesy Industry Railway Suppliers

5.7 Abrasives Stones, Wheels, and Blades

5.7.1 All Abrasive must:

a) Be fully or double reinforced;

b) Meet the maximum RPM rating for the type of equipment to be used;

c) Be of proper design and size for the type of equipment being used; and

d) Properly fit the tool with all safety guards in place. Safety guards must always be in place and never altered.

5.7.2 Only saw blades that are designated for rail cutting are allowed.

Figure 5-13: Rail Saw Blade Label
Courtesy Norton Abrasives

6 Grinding

6.1 Profiling Grinding of Rail

6.1.1 Preventive maintenance grinding prolongs rail and component life.

6.1.2 Abusive finish grinding of cold carbon steel rail, in particular alloy and head-hardened rail, can create a layer of untempered martensite caused by overheating and rapid cooling of the rail (called bluing).

6.1.3 All preventive and finish grinding of rail must be measured using a 36 in (914 mm) straight edge and a taper gauge. A tape measure and rail wear gauge will also be required for measuring tapered slopes for vertical and face offsets.

Figure 6-1: Starrett No.270 Taper Gauge

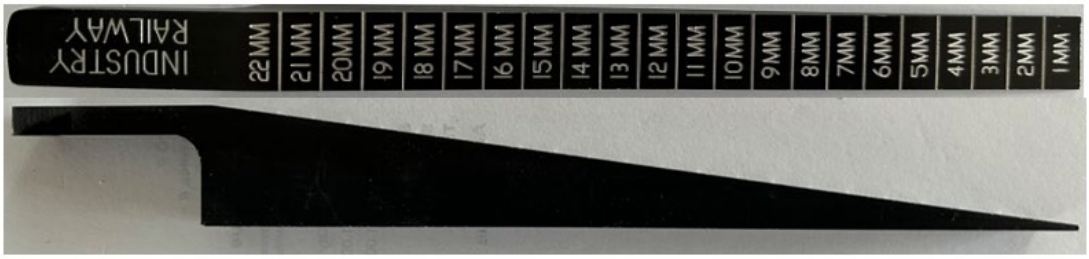


Figure 6-2: Large mm Taper Gauge

6.1.4 All finish grinding tolerances must be measured at a temperature at or below 200 °F (93 °C).

6.1.5 Rail profiles must be blended to match existing rail profiles:

a) Gauge and field corners of the rail head should be ground to a 3/8 in (10 mm) to 1/2 in (13 mm) radius;

b) In Class 3 Track and above, taper lengths must be sloped at a rate of 1 mm per 2 ft (0.039 in to 0.6 m) of offset in rail height;

Table 6-1: Taper Lengths for Class 3 Track and Above

OFFSET			GRINDING TAPER LENGTH (T) INCHES			
X (inches)	Fractional Equivalent For Maximum	MM Equivalent For Maximum	VERTICAL OFFSET	HORIZONTAL OFFSET		
				GAUGE		FIELD
				FACE	CURVE WEAR, FLOW LIP	WEAR, FLOW LIP
0.01			6	6	6	6
0.011 - 0.020		0.50 mm	12	12	12	6
0.021 - 0.030	1/32	0.76 mm	18	18	18	6
0.031 - 0.040		1.01 mm	24	24	24	6
0.041 - 0.050		1.27 mm	30	30	30	6
0.051 - 0.060	1/16	1.52 mm	36	36	36	6
0.061 - 0.080		2.03 mm	48	42	36	6
0.061 - 0.125	1/8	3.17 mm			42	6
0.126 - 0.188	3/16	4.77 mm			42	
0.189 - 0.250	1/4	6.35 mm			48	
0.251 - 0.313	5/16	7.95 mm			48	
0.314 - 0.375	3/8	9.52 mm			72	
0.376 - 0.500	1/2	12.7 mm			72	

c) All rail taper slopes on weld repaired joints in Class 1 and 2 Track must have a uniform taper with a minimum length of 12 in (305 mm);

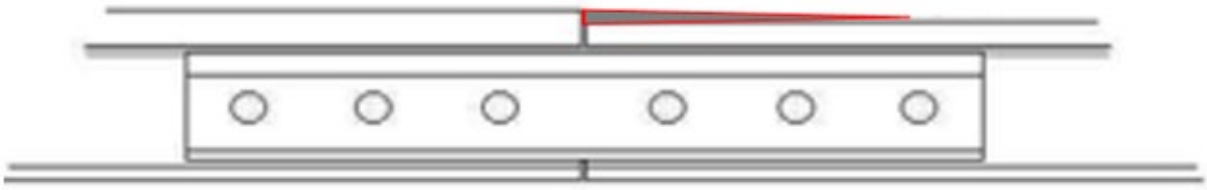


Figure 6-3: Taper Length at Rail Joints

d) All rail weld repairs will be finished ground to the following tolerances shown in the table below:

Table 6-2: Finished Weld Grinding Tolerances

Measurement	Dimension	Tolerance	
		Thermite Weld	EFB Weld
Crown: Peak of the rail at the weld	A	0.030 in (0.76 mm)	0.060 in (1.52 mm)
Vertical Offset: Vertical difference on the rail head	C	0	0.060 in (1.52 mm)
Dip Camber	E	0	0
Horizontal Offset: Horizontal difference on side of the rail head	B	0.015 in (0.38 mm)	0.040 in (1.01 mm)
Indent - Kink to field side	D	0.030 in (0.76 mm)	0.030 in (0.76 mm)
Intent – Crown inward (peak) toward track centre	D	0.030 in (0.76 mm)	0.60 in (1.52 mm)

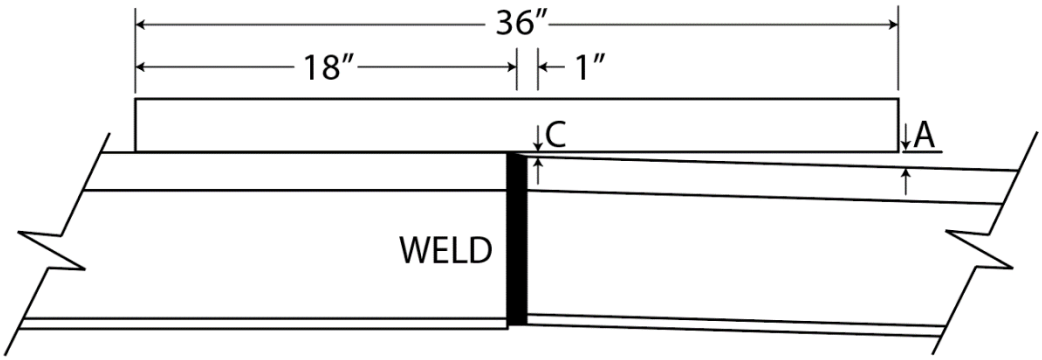


Figure 6-4: Vertical Offset at a Thermite or Flash Butt Weld

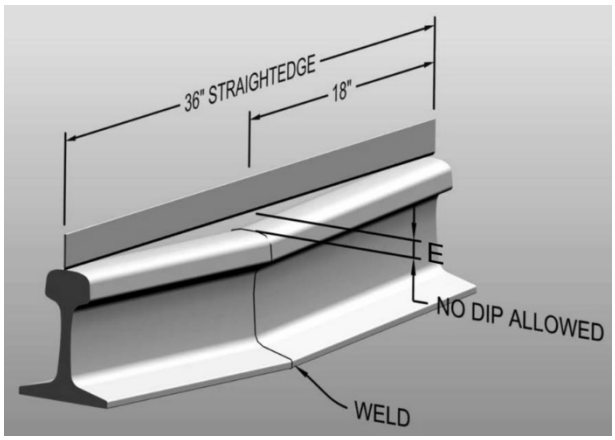


Figure 6-5: Dip Camber Tolerance at a Thermite or Flash Butt Weld

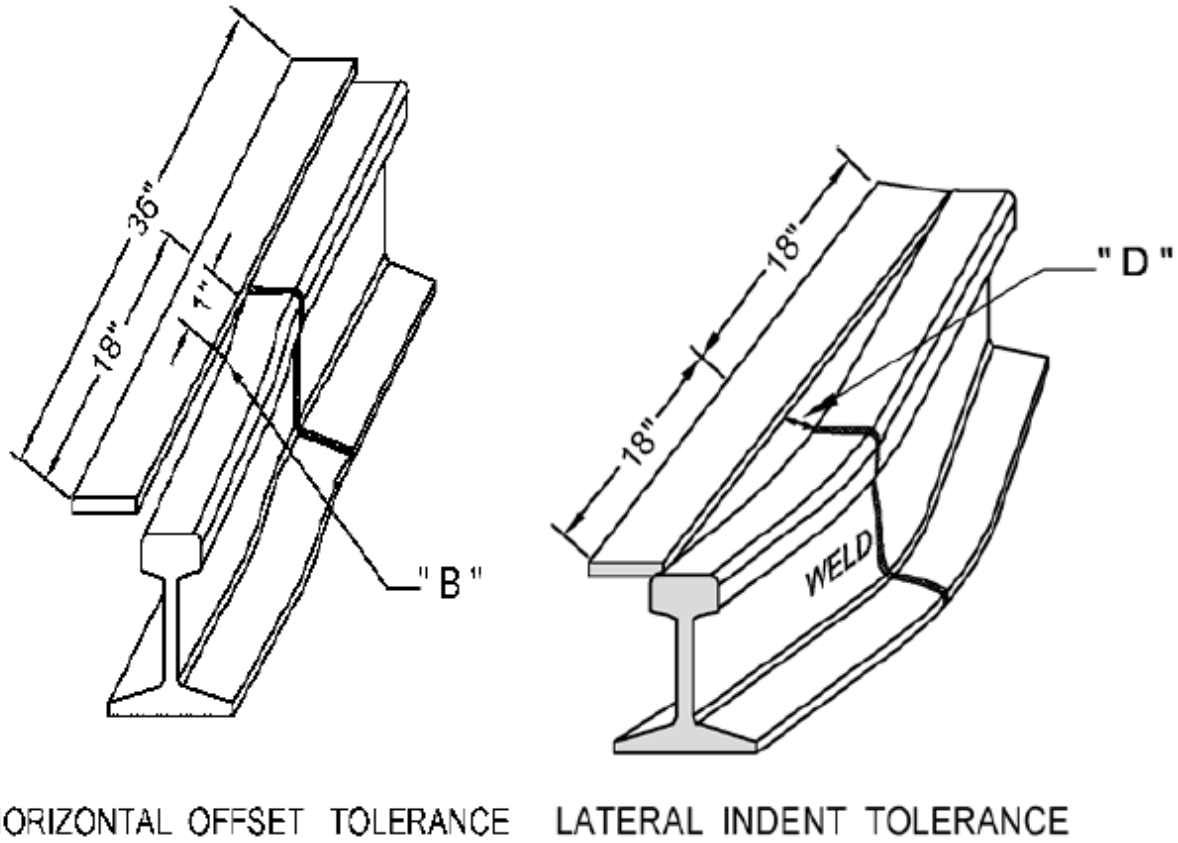


Figure 6-6: Horizontal Offsets at Thermite and Flash Butt Welds

6.1.6 All finish grinding of engine wheel burn weld repairs will match and conform to existing rail profiles and radii:

a) All engine burn weld repairs will be ground flat within a tolerance of 0.00 in low to + 0.015 high.

6.2 Switch Point and Stock Rail Grinding

6.2.1 Switch points and stock rails must be ground to ensure proper fit and adjustment as part of preventive maintenance.

6.2.2 New switch points and stock rails should be inspected frequently for flow/lip and/or unusual wear after installation:

a) Metal flow/lip must be removed by grinding;

b) Grinding must be performed several times until the component work hardens. This may take several months, depending on the tonnage.

6.2.3 All out-of-face (i.e., complete switch grinding) should be completed with an MC-2 or MC-3 type grinder. Handheld grinders can be used for touching up small areas.

Figure 6-7: MC-2 Grinder
Courtesy CN Training

6.2.4 After grinding, adjust the switch as necessary to ensure the proper fit of the switch point to the stock rail, prior to allowing any train movements:

a) It is the Welders' responsibility to have the proper tools and or personnel on hand to adjust the switch prior to allowing train movements;

b) Any point gap up to 1/8 in (3 mm) requires a speed restriction of 25 mph (40 km/h). Gaps greater than 1/8 in (3 mm) require the track to be taken out of service until proper fit is obtained.

6.2.5 **Safety Critical Rule:** Switch points and stock rails intended to be ground in signalled territory, must be supported with a signals work plan methodology approved by Metrolinx or its designate:

a) The S&C Maintainer must be notified in advance of any grinding affecting the switch point and stock rail fit;

b) The S&C Maintainer must inspect and make the necessary adjustments prior to restoring the switch to service.

6.2.6 Grind stock rails a minimum of 4 in (102 mm) ahead of the switch point tip, and a minimum of 3 ft (914 mm) beyond the switch point side contact (side planning) area with the stock rail:

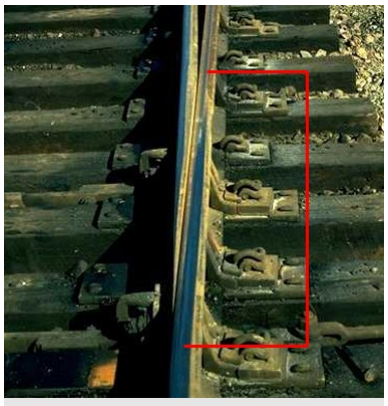


Figure 6-8: Switch Point Side Planing
Courtesy CN Training

a) Remove the overflow material on both the gauge and field side of the rail;

b) Re-establish the proper rail radii by grinding the gauge corner radius to approximately ¼ in (6 mm).

6.2.7 Inspect the switch to determine the switch type prior to grinding.

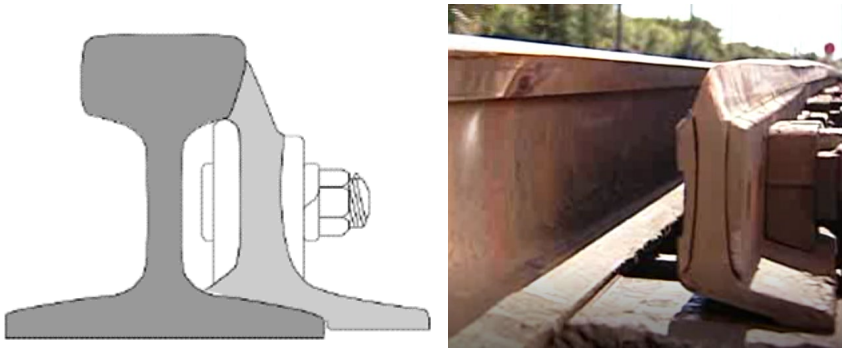


Figure 6-9: Samson Switch Point and Undercut Stock Rail
Courtesy CN Training

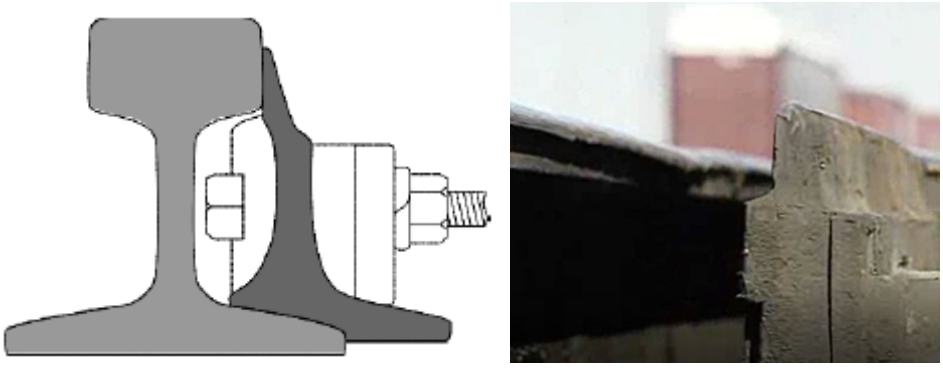


Figure 6-10: Knife (Conventional) Switch Point and Stock Rail

Courtesy CN Training

6.2.8 Adjust the grinder work head to conform to the type of switch point being ground. Do not grind into the switch point reinforcing:

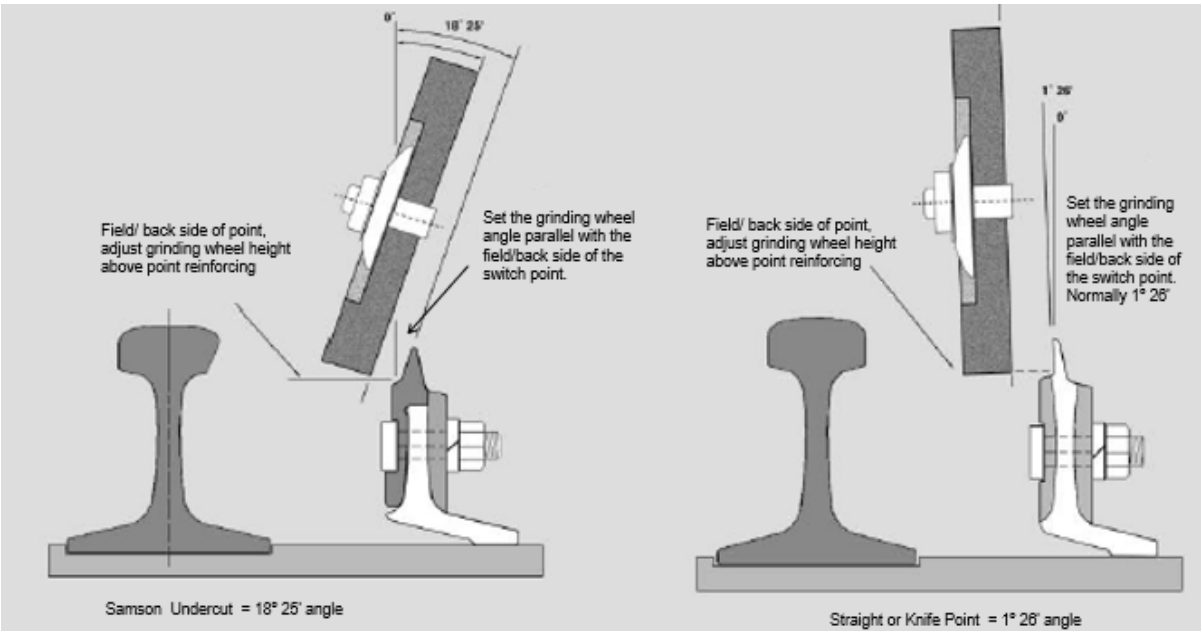


Figure 6-11: Grinding Work Head Angle

a) For a Samson switch point and undercut stock rail, use an angle of 18° 25′;

b) For a knife (conventional) switch point and stock rail, use an angle of 1° 26′.

6.2.9 Grind the back side of the switch points and matching stock rail to achieve an even uniform fit of the mating surfaces.

6.2.10 Grind the gauge side of the switch points, adjust the work head to an angle of approximately 12° grinding only the planed area of the switch point:

a) After completing the gauge side planed area of the switch point, return the work head angle back to an angle of 1° 26′ and finish the remaining rail face angle, removing any flow/lip;

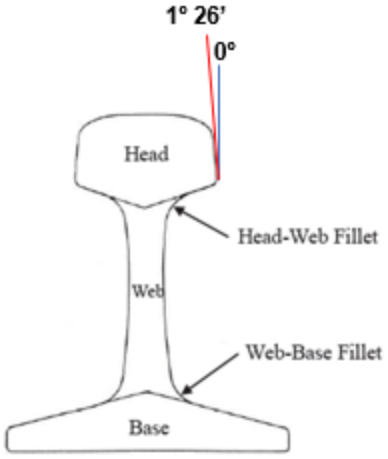


Figure 6-12: Rail Head Angle

6.2.11 Re-establish the radius on the gauge corner matching the existing rail profile:

a) Establish a 1/2 in (13 mm) radius on the gauge corner from the heel of the switch point to the end of the side planing on the gauge side of switch point.

6.2.12 If the switch point is worn down, chipped, or broken more than 7/8 in (22 mm) below the plane across the stock rail, then:

a) Replace the switch point if in Class 2 Track and above; or

b) Weld repair only:

i. If in Class 1 Track; and

ii. If the area to be welded is less than 12 in (305 mm) in length.

6.2.13 The finished ground switch point tip should be approximately 5/8 in (16 mm) below the plane across the stock rail:

a) The switch point will slope evenly upwards to the top plane of the stock rail. This length will be determined by the length and size of the switch;

i. **Example:** a 16 ft 6 in (5 m) knife (conventional) switch point has approximately a 36 in (914 mm) slope.

b) The front of a knife switch point should have a 1 ½ in (37 mm) radius; and

c) The gauge corner of a switch point should have a ¼ in (6 mm) radius.

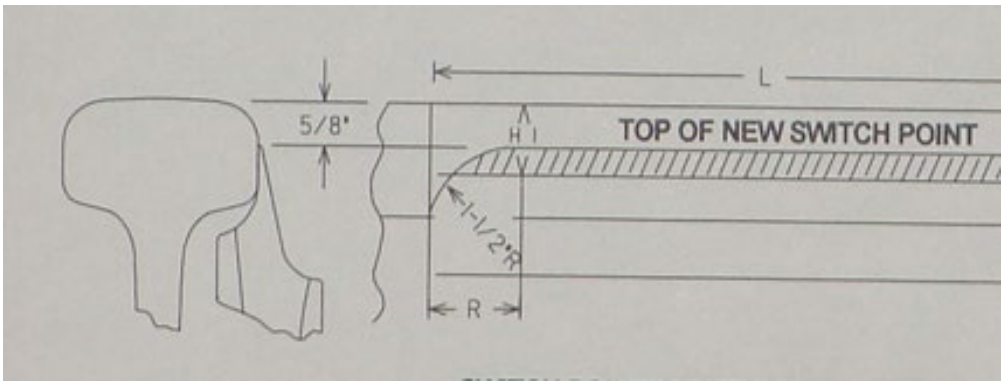


Figure 6-13: Knife Switch Point Dimensions

Figure 6-14: Examples of Knife Switch Point Grinding after Weld Repair
Courtesy CN Training

6.2.14 Prior to returning to service, ensure the switch is adjusted correctly, swept clean of all grinding debris, and properly lubricated:

a) If in a signalled territory, the S&C Maintainer must inspect and adjust correspondence with the signal system.

6.3 Slotting of Rail

6.3.1 Preventive slotting and grinding of flow/lip prevents costly repairs.

Figure 6-15: Overflow at Joint
Courtesy CN Training

6.3.2 Rail end flow/lip must be removed at joints by slotting in accordance with the Metrolinx Track Standards (formerly GTTS) and Standard Plans (GTS – 1113).

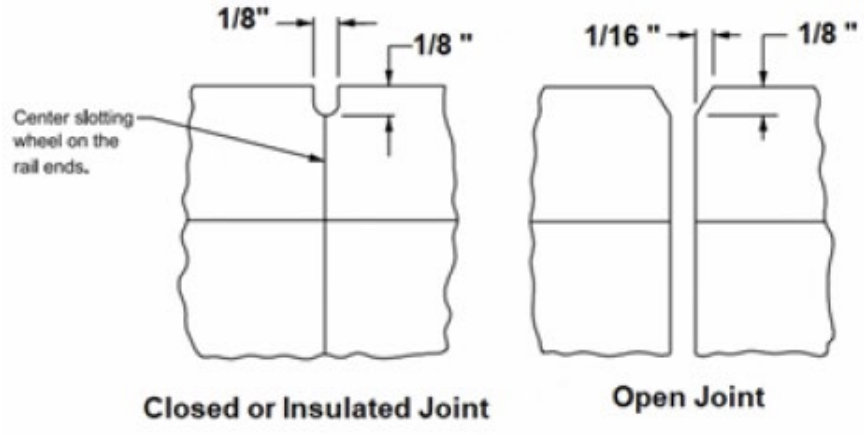


Figure 6-16: Open and Closed Joints After Slotting

6.3.3 After slotting insulated joints, the gap should be filled with a silicone sealer to prevent the influx of dirt and grind material.

6.3.4 If in signalled track, care must be taken not to cut joint bonding wires.

6.3.5 All weld-repaired joints must be slotted below the weld repair area, as shown in Figure 6-17 and Figure 6-18 below.

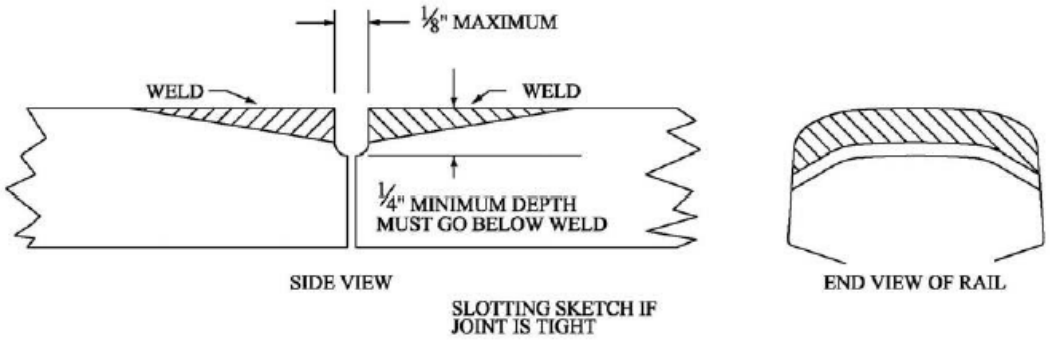


Figure 6-17: Slotting at a Closed Joint

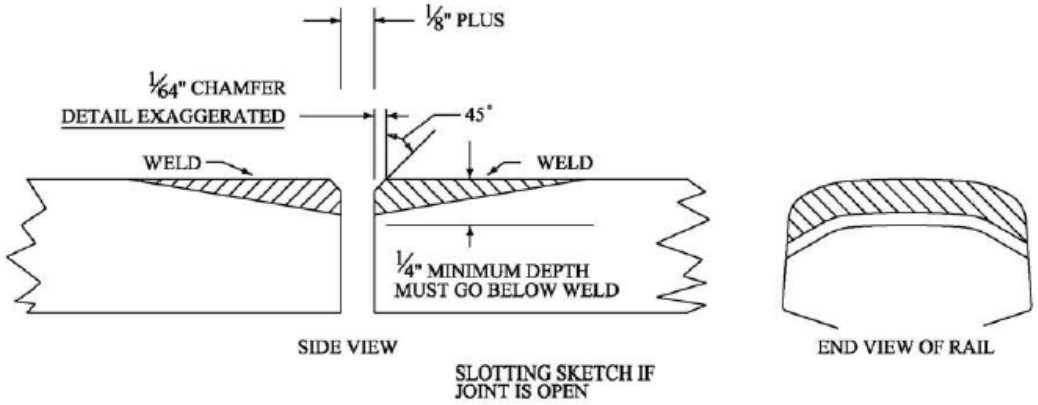


Figure 6-18: Slotting at an Open Joint

6.3.6 Do not slot cut into the joint bar.

6.3.7 Rail slotting wheel/disk/stone should be 1/8 in (3 mm) thick and be a proper fit for the size and diameter of the grinder being used:

a) Care must be taken not to twist or apply excessive side pressure while slotting.

6.4 Preventive Grinding of Frogs and Diamond Crossings

6.4.1 Prior to grinding any frog, diamond crossing, or other component, ensure that they are in compliance with all wear tolerances contained in the GTTS and Transport Canada *Rules Respecting Track Safety*:

a) If found out of compliance, take the proper remedial action.

6.4.2 Preventive maintenance grinding must be done as soon as possible when metal flow is noted. A scheduled grinding maintenance plan must be in place for all new installations.

a) Always attempt to prolong the life of all track components by grinding, slotting, and monitoring them. All scheduled preventive grinding and slotting intervals must be maintained to remove flow and lip:

i. Document any work, in case of a warranty claim. All work must be recorded on daily welding reports, and submitted to Metrolinx Maintenance Delivery;

ii. New installations or completed weld repairs must be ground within the first 2 months after installation or repair;

iii. Then additional grinding may be required before metal flow reaches 1/6 in (1.5 mm);

iv. Monitor for flow and lip and perform additional preventive grinding until the component has work hardened.

b) Grinding should be the primary maintenance technique for all track components. An effective grinding program will delay the need for repair welding and reduce the amount of welding required;

c) If it does not need welding, grind to prevent premature failures and welding repairs.

6.4.3 Metal flow, which reduces the flangeway dimensions of frogs and diamond crossings, will crack or spall and must be removed by grinding.

6.4.4 Flangeways should be ground clear of flowed metal to a standard of 1 7/8 in (48 mm) clearance, and the flangeway walls properly sloped to match existing contours.

6.4.5 All spring frogs, self-guarded manganese, diamond crossing inserts, rigid frogs, and 1/2 in (12 mm) point RBM frogs will be ground to a 3/8 in (10 mm) radius.

6.4.6 Heavy point RBM frogs, conformal heavy point frogs, jointless-boltless manganese (JBM), and welded heel manganese (WHM) will be ground to a 9/16 in (14 mm) radius.

6.4.7 All frogs (except conformal frogs) have a 3/16 in (5 mm) point taper.

a) At the half-inch point of the frog, the point is 3/16 in (5 mm) lower than the wing rail. It tapers back to a distance of one-half the number of the frog size.

b) **Example:** A number 12 frog will be sloped 3/16 in (5 mm) for a distance of 6 in (152 mm) back (12 x .5 = 6 in).

c) ***Note:*** Spring frogs, conformal frogs with a 1:20 tread and wing slope or rigid frogs do not have point tapers.

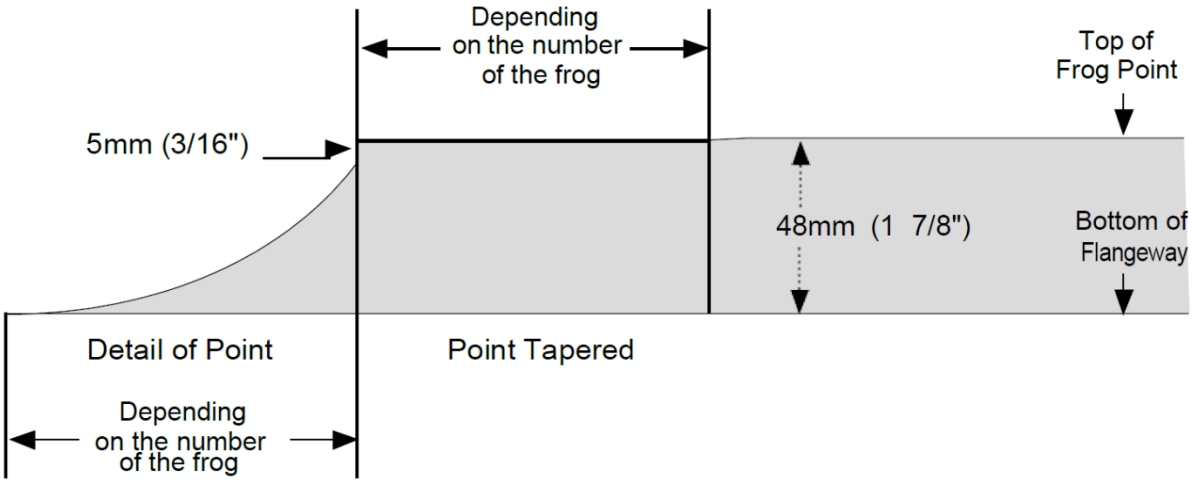


Figure 6-19: Frog Point Details

6.4.8 The gauge corners of frog points and wing rails should be ground to remove flow and restore radii.

6.4.9 Use an approved flangeway gauge to determine the accuracy of frog and diamond crossing contours and radii.

Figure 6-20: Flange and Radius Check Gauge, Heavy Point and Standard Point Flange Radius Gauge

Courtesy Industry Railway Suppliers and DAVANAC

6.4.10 All contact bands of mating surfaces and joint overflow must be removed by slotting to a depth of ¼ in (6 mm).

Figure 6-21: Slotting Frog Heel Rail Contact Mating Surface
Courtesy CN Training

6.4.11 Identification of frog size by number.

a) This can be found on the frog tag or stamped in the casting. If these markings are not visible, determine the frog size number by:

i. Using a tape measure, find the location where the frog point width is 3 in (76 mm) as measured from gauge line to gauge line. Place a line across the point at this location;

ii. Find the location where the frog point width is 4 in (102 mm) as measured from gauge line to gauge line. Place a line across the point at this location;

iii. Measure between these marks. The number of inches measured between the two lines will equal the frog size number.

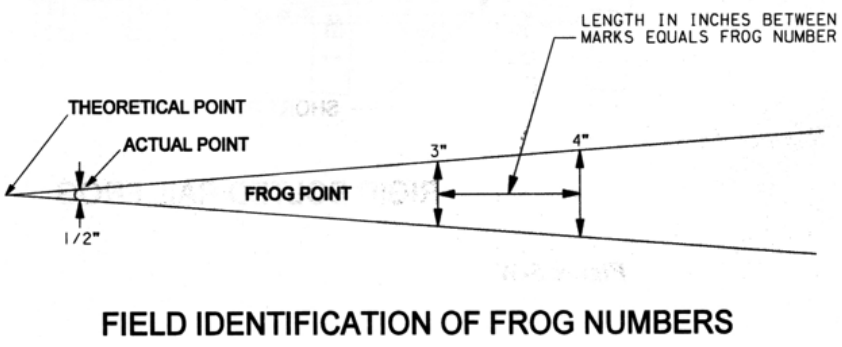


Figure 6-22: How to Determine a Frog Number

6.4.12 Standard ½ in point frog will be ½ the number of the frog size (½ in = 0.5).

a) **Example:** For a number 12 frog, the frog point will be 6 in (153 mm) from the theoretical point of the frog (12 x 0.5 = 6).

6.4.13 Heavy point frog, the point will be set back from the theoretical point 5/8 the number of the frog. (5/8 in = 0.625).

a) **Example:** A number 12 heavy point frog the point will be 7 ½ in (190 mm) back from the theoretical point of the frog (12 x 0.625 = 7.5).

6.4.14 The theoretical point is where the gauge lines cross. This is normally stamped or marked on manganese frog castings.

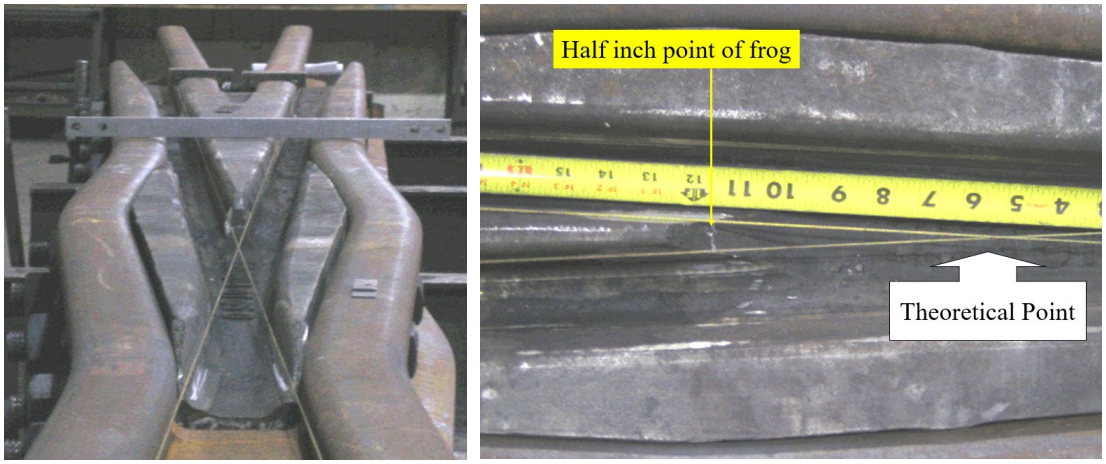


Figure 6-23: Determining the Theoretical Point of a Frog

Courtesy CN Training

6.5 Spring Frogs

6.5.1 Beyond routine inspections, spring frogs must be checked for broken, cracked or missing brace stops, braces, horns, and holddown housings:

a) The spring wing must lay flat on base plates;

b) The clearance between the horn and the holddown housing must not exceed ¼ in (6 mm).

6.5.2 Prior to grinding, the spring wing rail at the heel must be opened and secured with blocking to allow free travel for grinding.

6.5.3 Spring wing rail must fit tightly against the point rail. The spring frog is designed to be open 3/8 in (10 mm) at the half-inch point of the frog.

6.5.4 Spring frogs are to be ground to a 3/8 in (10 mm) radius and checked using a standard regular point frog gauge.

6.5.5 The spring wing base plate must be cleaned of all grinding materials and metal filings and be appropriately lubricated.

6.5.6 Remove blocking from the spring wing prior to returning to service.

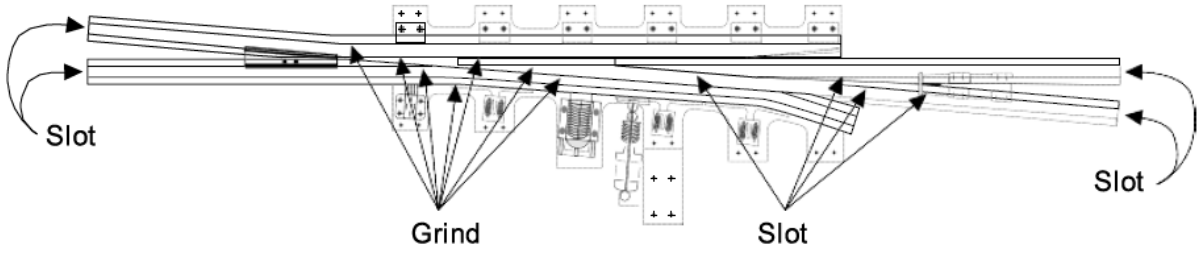


Figure 6-24: Spring Frog Grinding and Slotting Areas

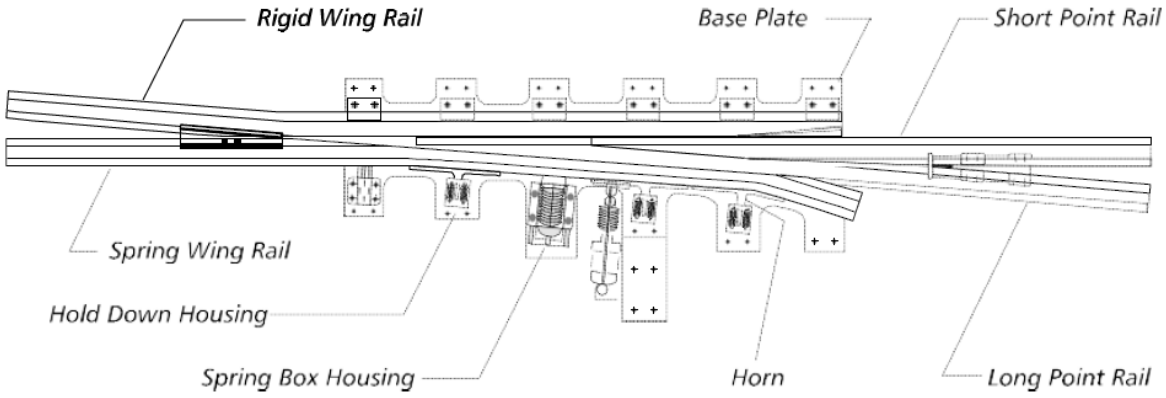


Figure 6-25: Spring Frog Components

6.6 Flange Bearing or One-Way Low Speed (OWLS) Frogs and Diamond Crossings

6.6.1 All metal flow will be ground with proper radii restored and all mating surfaces slotted.

Figure 6-26: OWLS Frog and Railroad Crossing

Courtesy CN Training

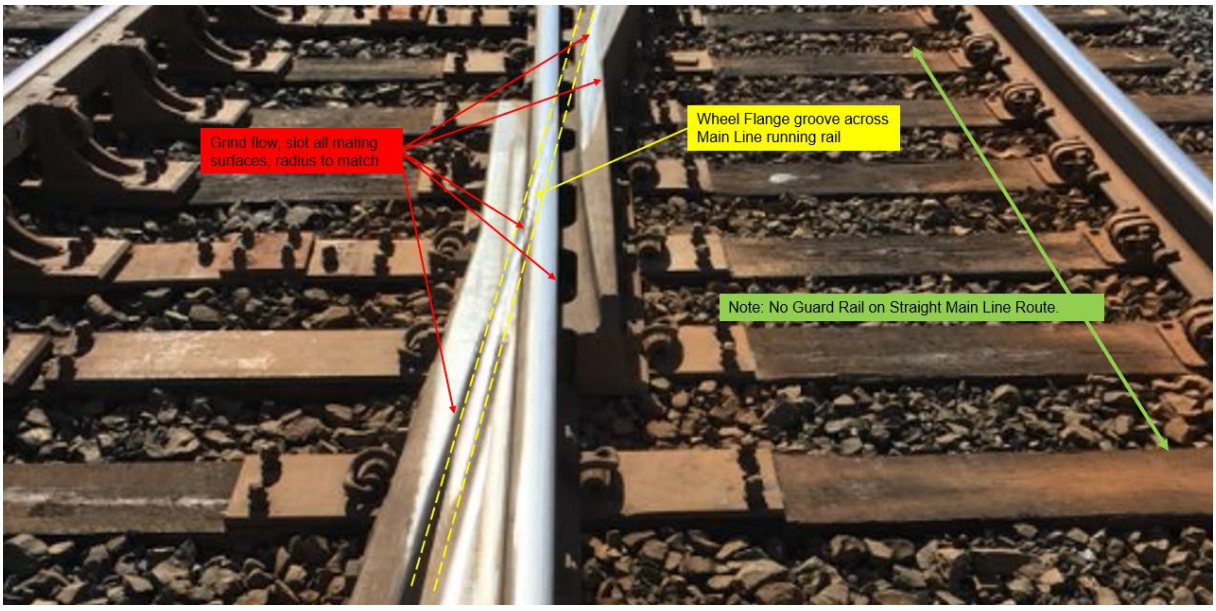


Figure 6-27: OWLS Frog Grinding and Slotting Areas

Courtesy CN Training

Figure 6-28: Grinding Areas on a Flange Bearing Railroad Crossing
Courtesy CN Training

6.6.2 The flange groove across the main line running rail cannot be repaired by welding; Grinding is the only method of repair:

a) Flange bearing frogs and diamonds must be maintained so that the groove in the main line running rail does not exceed ½ in (13 mm).

6.7 Moveable Point Frog

6.7.1 The grinding procedures for the frog point and wing rails are similar to grinding a switch point and stock rail.

6.7.2 All moveable point frogs intended to be ground, must be supported with a signals work plan methodology approved by Metrolinx or its designate.

6.7.3 The S&C Maintainer must be notified in advance of any grinding affecting the frog point and wing rail fit.

6.7.4 Prior to performing any work, obtain local control and ensure that both the switch and frog are off power and in hand operation.

6.7.5 All metal flow will be ground with proper radii restored and all mating surfaces slotted.

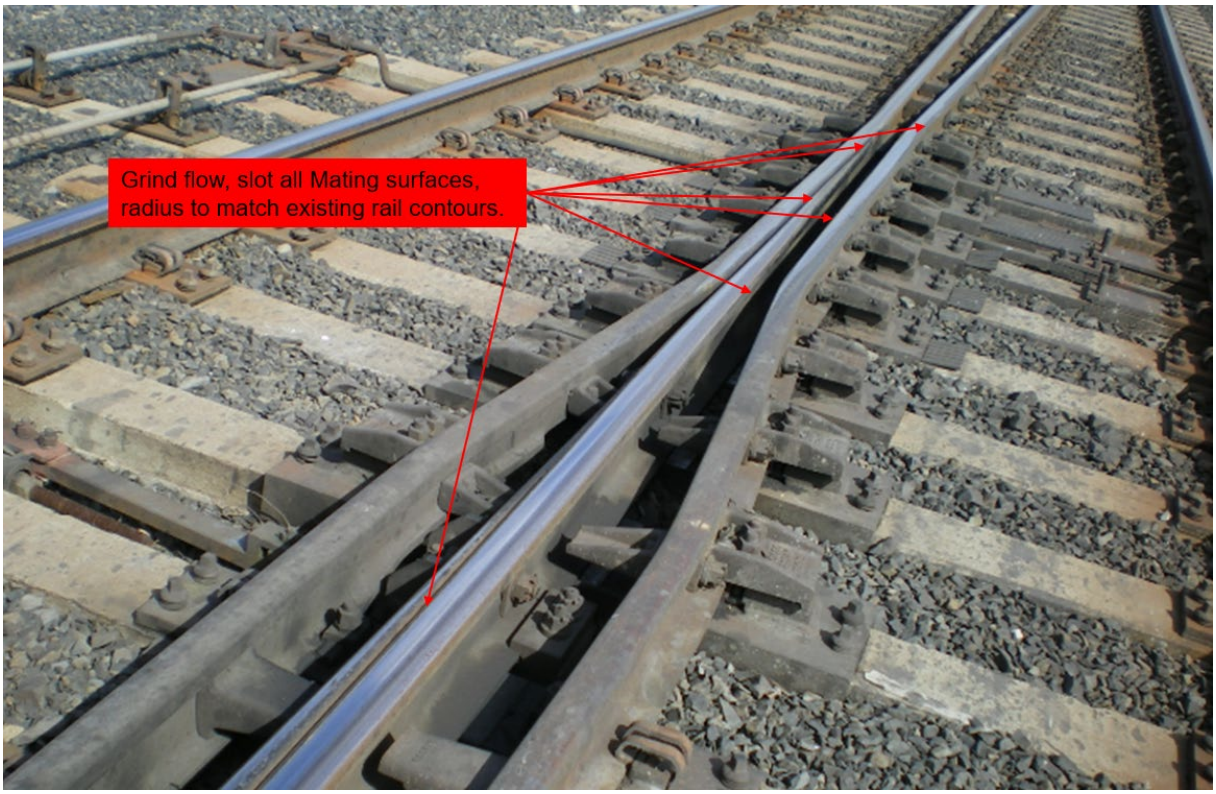


Figure 6-29: Grinding and Slotting Areas on Moveable Point Frog

Courtesy CN Training

6.7.6 Prior to returning to service, ensure that the frog point is properly adjusted, the plates swept clean of all grinding debris, and properly lubricated.

6.7.7 The S&C Maintainer must inspect and make necessary adjustments for correspondence with the signal system prior to restoring to service.

6.8 Manganese Castings

6.8.1 There are many types of Rail Bound Manganese (RBM) frogs. Check the tag to determine the type of frog that is being worked on.

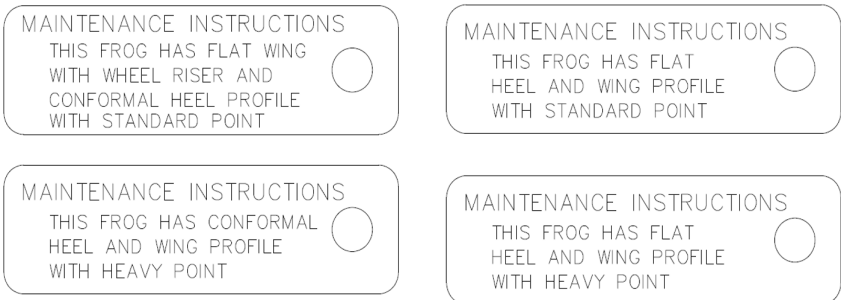


Figure 6-30: Frog Tag Maintenance Instructions

6.8.2 Standard point RBM frog will have a flat top with a 90° heel and a ½ in (12.7 mm) point:

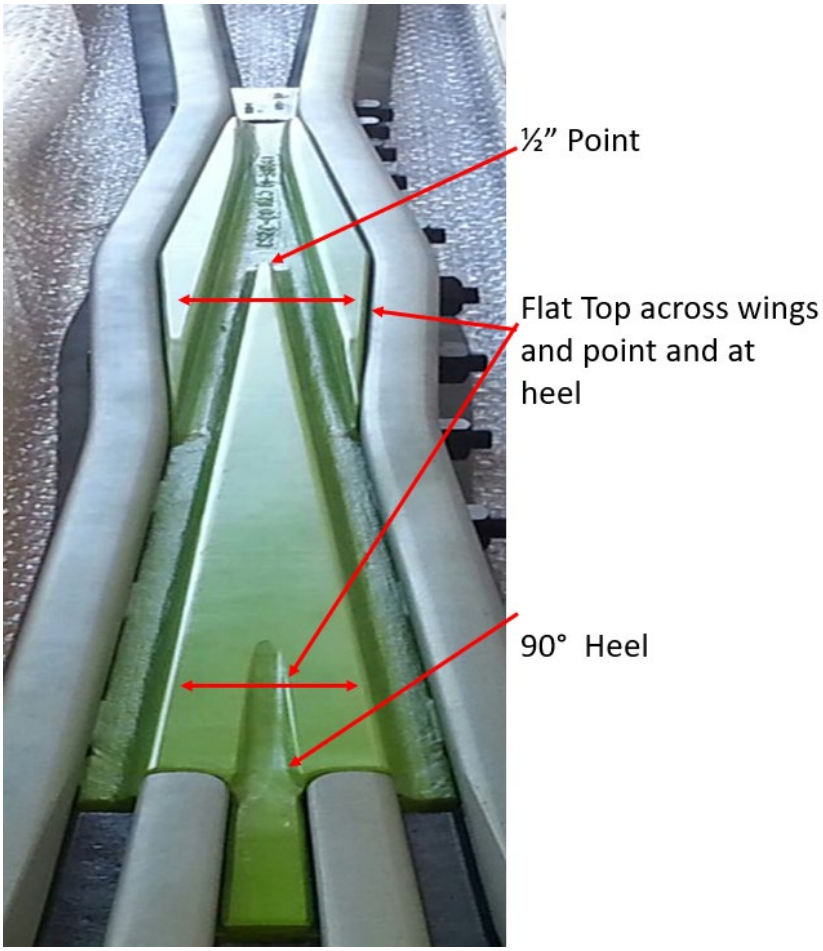


Figure 6-31: Standard RBM Frog with 1/2" Point Frog
Courtesy CN Training

a) The identification tag for a standard RBM frog is on the frog bolt near the centre of the frog;

Figure 6-32: DAVANC (Regular Point) Flange Radius Gauge

b) Standard RBM ½ in point frog will be ground to 3/8 in (10 mm) corner radius. The flange gauge can be used to check wing or point radii.

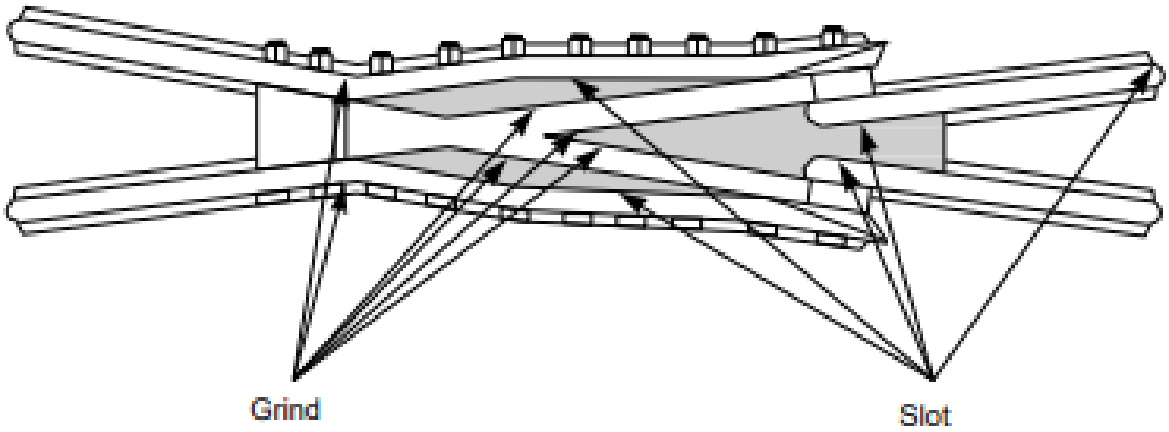


Figure 6-33: Standard ½" Point RBM Frog Grinding and Slotting Areas

6.8.3 Heavy point RBM frog:

a) Always check the frog ID tag to determine the type of heavy point frog prior to performing repairs or maintenance grinding;

Figure 6-34: Heavy Point Frog Flat Top ID Tag

Figure 6-35: DAVANC Heavy Point Frog Radius Gauge

Courtesy CN Training

b) Heavy point frogs will be ground to 9/16 in (14 mm) corner radius. The flange gauge can be used to check both the wing and point radii;

c) **Reminder:** Heavy point frog castings are measured at 5/8 times the number of the frog from the theoretical point. The frog number x .625 = distance.

6.8.4 Conformal RBM frog:

a) Conformal frogs can come in various designs; always check the frog ID tag prior to performing repairs or maintenance grinding;

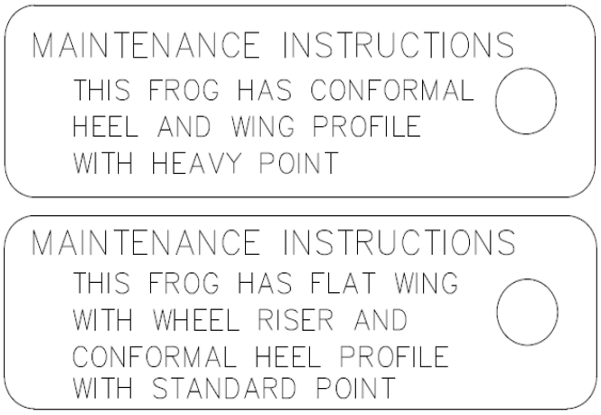


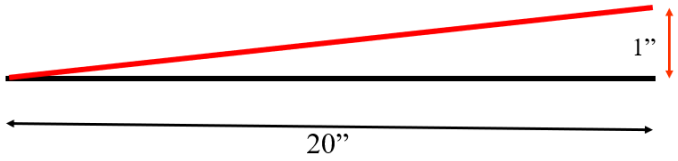
Figure 6-36: Conformal Frog Maintenance Instruction Tag

b) Conformal frog slope of 1:20 (3° degrees) is designed to match new wheel tread profiles;

Figure 6-37: New Wheelset Gauge Showing Contour Wheel Tread Slope 1:20

Courtesy CN Training

c) Explanation of a 1:20 slope;



The red line will raise 1” in 20”

Figure 6-38: 1:20 Slope Diagram

Courtesy CN Training

d) A frog with a heavy point and tapered universal heel rails does not mean it is a conformal frog. Check the frog tags to make sure;

Figure 6-39: Tapered Universal Heel Rails of Conformal HP Frog

Courtesy CN Training

e) Conformal frog gauge sets must be used to determine the allowable tread wear, flangeway depth and 1:20 (3° degree) tread slope:

   i. After weld repairs, conformal frogs must be restored by grinding to original design contours;

   ii. A precision frog grinder with an adjustable work head is best suited for grinding the 1:20 (3° degree) tread slope angle; and

   iii. Know and understand what type of frog is being repaired to ensure compliance with the GTTS and Transport Canada *Rules Respecting Track Safety*.

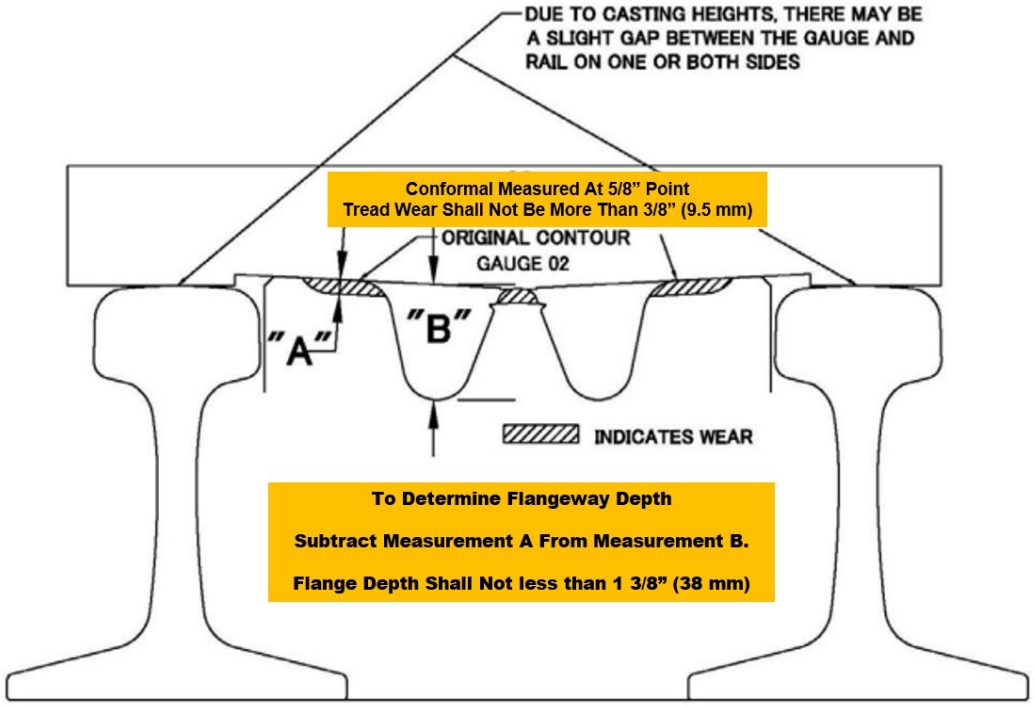


Figure 6-40: Conformal Frog Gauge 02 Showing Wear Limits

Courtesy CN Training

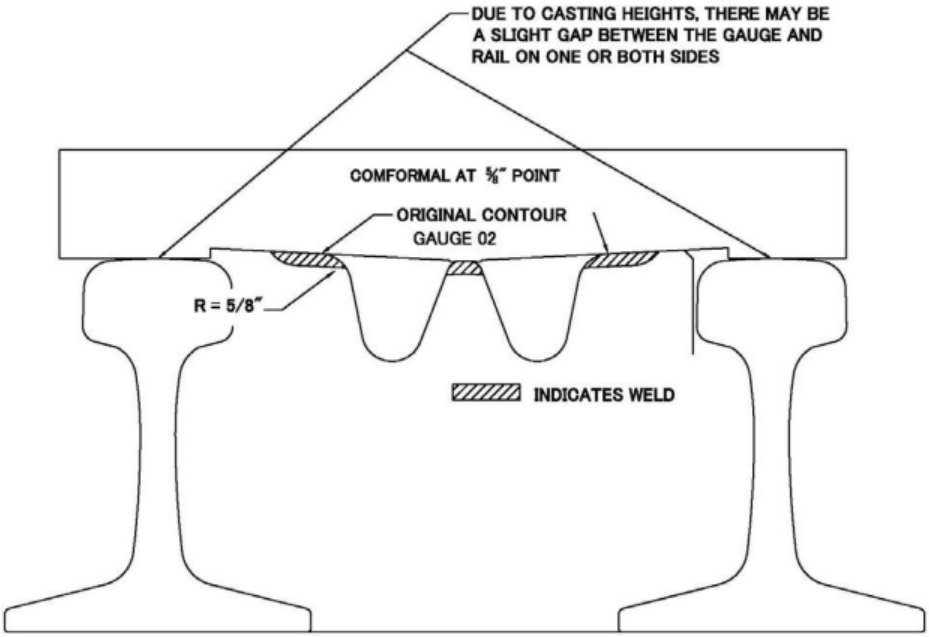


Figure 6-41: Conformal Frog Weld Repair Restored to Original Contours
Courtesy CN Training

f) **Reminder:** Conformal heavy point frog design does not contain a tapered slope as in a traditional non-conformal (flat top) frog:

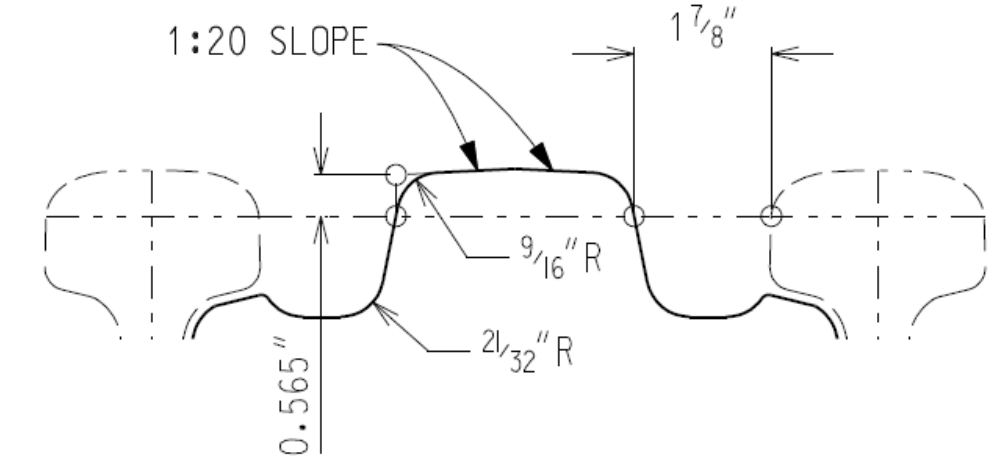
   i. Proper gauges must be used to check the 1:20 design angle.

g) There are various conformal frog gauge sets that must be used depending on the design and frog number. Ensure that the gauge set matches the type of frog being ground or repaired;

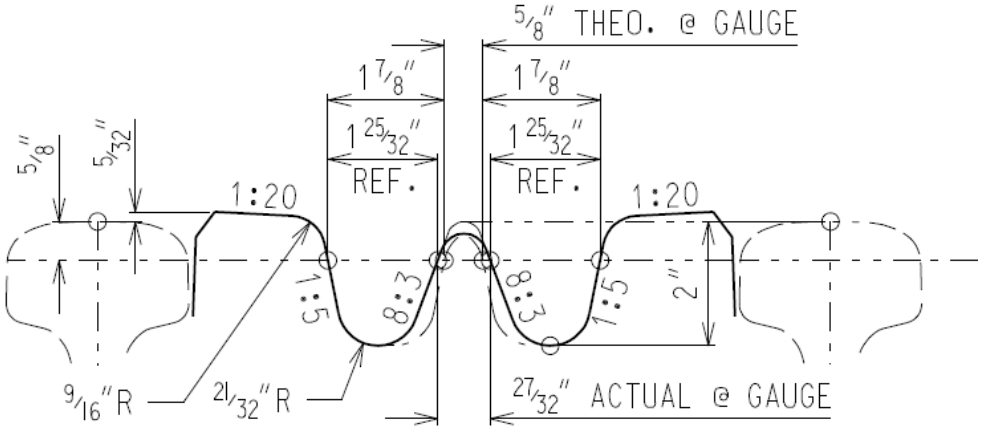
Figure 6-42: IRS 732 Conformal HP Frog, 2-Gauge Set
Courtesy Industry Railway Suppliers

Figure 6-43: IRS 728 Conformal HP Frog, 3-Gauge Set
Courtesy Industry Railway Suppliers

h) Drawing examples below show slopes and radii for reference. Note that there may be slight differences between the various frog manufacturers;



1:20 SLOPE TOP RUNNING SURFACE DETAIL



SECTION VIEW AT 5/8" POINT

Figure 6-44: Frog Surface Dimensions

6.8.5 Self-guarded manganese frog:

Figure 6-45: Self-Guarded Manganese Frog
Courtesy CN Training

a) Use the proper self-guarded frog gauge to inspect for wear, shape and frog profile radii;

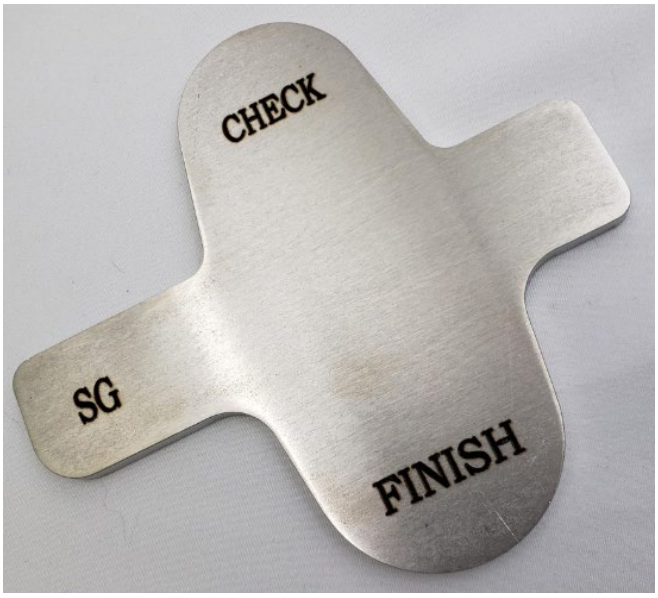


Figure 6-46: Self-Guarded Manganese Frog Check Gauge
Courtesy Industry Railway Suppliers

b) If the guarding face wear exceeds ¼ in (6 mm), then schedule for repair welding; and

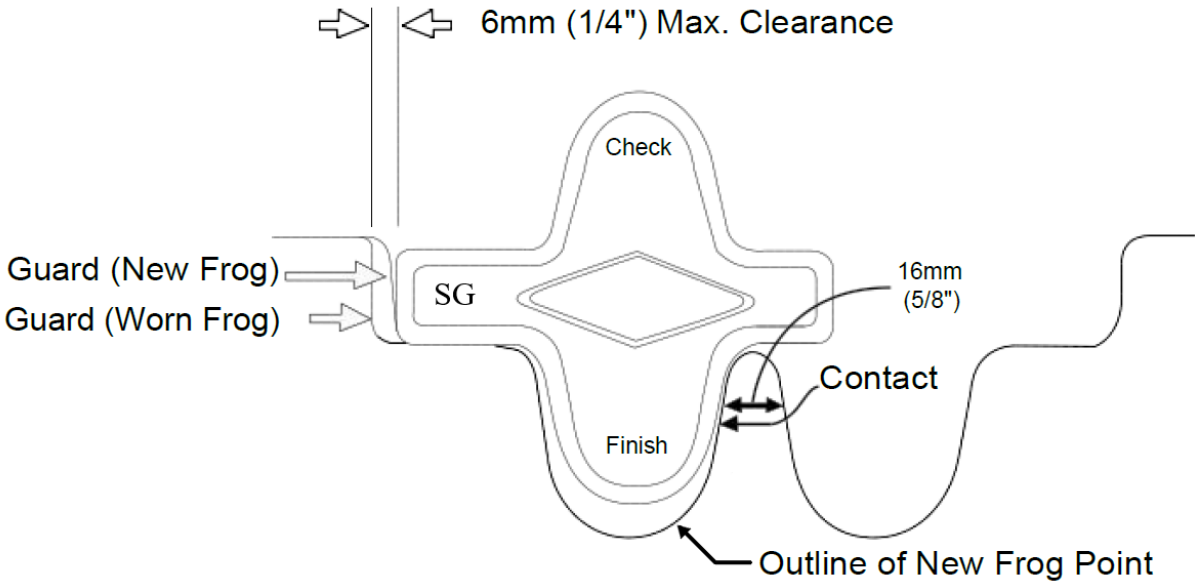


Figure 6-47: Self-guarded Manganese Frog Check Gauge

c) If the raised guard is worn more than 3/8 in (10 mm) from the original contour of the non-worn area of the raised guard, the frog must be taken out of service, until replaced or weld repairs are made.

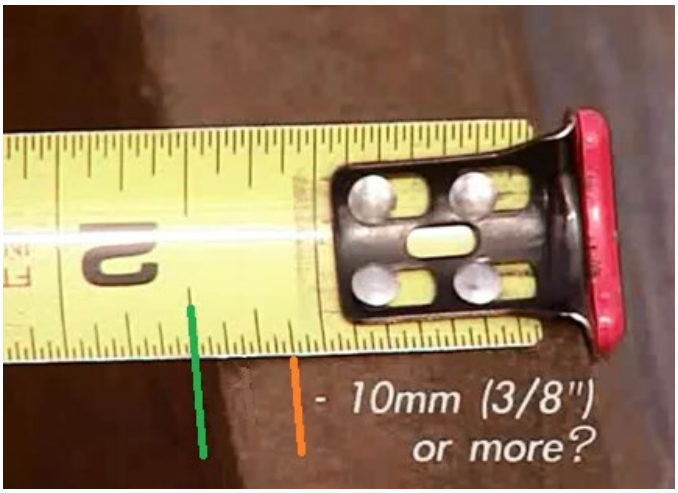


Figure 6-48: Self-Guarded Manganese Frog Measuring Raised Guard Wear

Courtesy CN Training

6.8.6 Diamond (or At Grade Rail to Rail) crossings:

a) Diamond crossings will vary in shape and design depending on the angle of the opposing route of traffic;

Figure 6-49: RBM Railroad Crossing Diamond

Courtesy CN Training

b) Track surface and alignment is critical to maintain proper flange and gauge width measurements:

i. Keep all fasteners tight; and

ii. Ensure all rail stop braces are in place.

c) RBM slotting and grinding areas are shown in the diagram below.

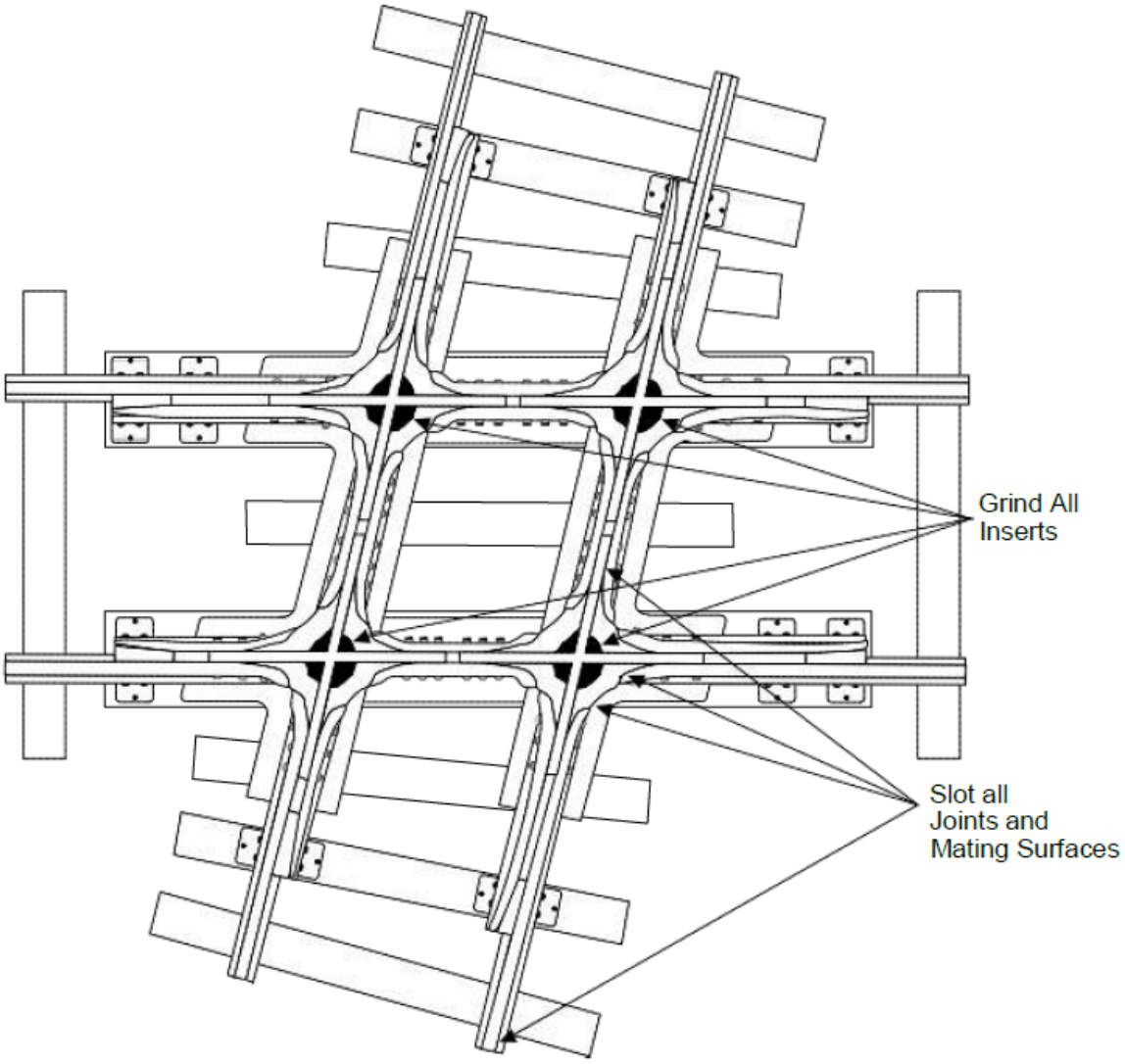


Figure 6-50: RBM Railroad Crossing Diamond Grind and Slotting Areas

7 Electric Weld Repair of Carbon Steel

7.1 Welding Precautions

7.1.1 Only those Welders who have been trained and certified are allowed to make weld repairs on carbon steel rail, including the carbon steel rail in frogs and diamond crossings.

7.1.2 Welding and grinding are considered Hot Work, and all safety, fire risk, and PPE requirements must be followed.

7.1.3 Welders are recommended to wear a respirator while welding and grinding on any carbon steel rail or components.

Figure 7-1: Types of respirators
Courtesy 3M and Pandrol

7.1.4 **Safety critical rule:** If the component to be welded cannot be properly preheated or post-heated, it must not be welded. It is crucial that all preheating, maintaining heat input while welding and post-heating be diligently performed to obtain a quality weld repair.

7.1.5 When welding on carbon steel rail or components, don't:

a) Weld if the ambient air temperature is below 5 °F (-15 °C), or

b) In heavy moisture conditions such as rain, sleet, blowing snow.

7.1.6 Only weld if:

a) The weld area can be protected from weather elements using shields, umbrellas, or welding tents; and

b) Properly preheated, heat input while welding and post-heating temperatures can be maintained.

7.1.7 Ensure that positive track protection is in place prior to performing any preparatory or repair welding work.

7.2 Weld Repair of Carbon Steel Rail

7.2.1 Follow the procedure below when making repairs to carbon steel rails:

a) Clean areas to be welded of all oil and grease by scraping and wire brush;

b) Place the work/ground clamp on the same rail and as close as possible to the weld work area by:

   i. Cleaning the area where the ground is to be clamped to prevent any arc burns; and

   ii. Attach the work/ground clamp to the head of the rail.

c) Remove any cracks, chips and all defective material by grinding;

d) ***Note:*** Don't use an oxy/fuel gas cutting torch, air carbon arc cutting, or electrode cutting rods.

e) Remove a minimum of 1/8 in (3 mm) of the work-hardened material from all worn areas requiring build-up repair;

f) Dye penetrant test all weld repair areas after grinding out the defective area and prior to performing any welding;

g) Control and measure heat input into the work area using the following temperature-measuring tools:

   i. Temp sticks;

   ii. Lazer temperature gun.

h) Control the proper preheating of all carbon steel rail and rail components prior to welding by using the appropriate heating equipment, torches, or heating blocks;

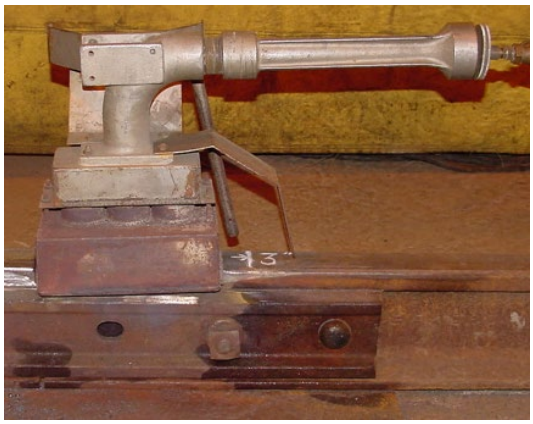


Figure 7-2: Typical Rail Heater
Courtesy CN Training

i) Preheat the weld repair area plus at least 3 in (76 mm) on either side of the repair area to a minimum of 700 °F (371 °C) but not exceeding 1000 °F (538 °C);

j) Maintain this temperature range, 700 to 1000 °F (371 to 538 °C) during the entire repair;

Figure 7-3: Measurement of Rail Temperature
Courtesy CN Training

k) Use only wire or electrodes specifically designed for welding on carbon steel rail:

   i. The recommended method is to use Flux Cored Arc Welding (FCAW) with 5/64 in (2 mm) diameter wire;

   ii. The Shielded Metal Arc Welding (SMAW) method using stick electrodes may also be used.

iii. Use the following larger diameter electrodes (as the area to be built and to maintain preheat temperatures while welding):

1) 3/16 in (5 mm) diameter, or

2) 1/4 in (6 mm) diameter.

l) Use weave beads not exceeding 1 in (25 mm) in width for both the FCAW and SMAW process;

m) Run the first few passes to fill the deepest ground-out areas at 90° to (across) the rail head;

n) Run the final build-up pass parallel to the direction of wheel travel;

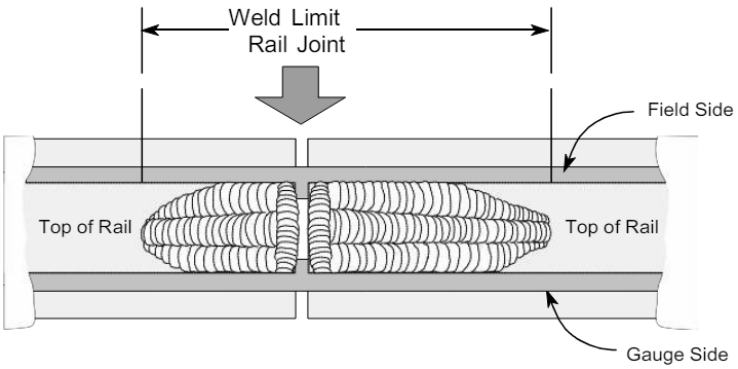


Figure 7-4: Example of Weld Bead Pattern

o) Don't end weld stops straight across (at 90° to) the rail head. Use a minimum of 1 in (25 mm) offset. See Figure 7-5 below;

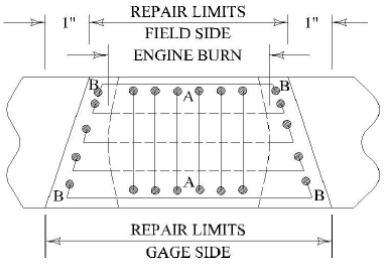


Figure 7-5: Diagram of Engine Burn Repair and Weld Weave Pattern

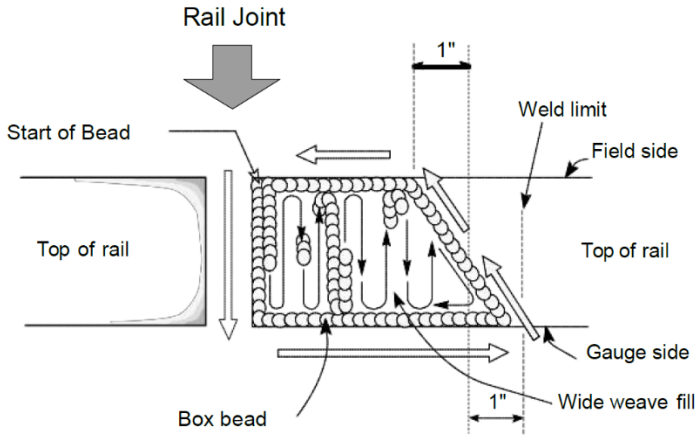


Figure 7-6: Example of Welding Bead Pattern and Minimum Weld Offset

p) On frog points and switch points, alternating parallel travel direction from toe to heel and then heel to toe is acceptable. This also helps reduce internal stress;

q) After welding each bead, clean slag with a needle scaler or a chipping hammer and wire brush:

   i. Clean slag from the bead start towards the bead finish (cold to hot).

r) After cleaning each bead:

   i. Peen the bead using a 2 lb (0.9 kg) ball peen hammer;

   ii. Use 3 to 4 blows per inch of weld bead; and

   iii. Peen from the bead finish towards the bead start (hot to cold) to reduce stress.

s) Monitor the temperature of the weld area frequently between passes, taking measurements:

   i. On the flangeway wall 1/4 in (6 mm) below the weld bead; or

   ii. Alongside the weld bead 1/2 in (12 mm) away.

t) If the welding operation is interrupted for any reason:

   i. Regrind any work-hardened areas;

ii. Reheated the weld area to the proper welding temperature of a minimum of 700 °F (371 °C) not exceeding 1000 °F (538 °C) prior to resuming welding.

u) Continue the welding repeating process until the height of the completed weld area is slightly higher than the required finished dimensions of the rail or component profile:

i. Do not peen the final layer passes to avoid dimples in the finished grinding.

Figure 7-7: Weld Area and Post-Heat Measurement
Courtesy CN Training

v) Post Heat the entire weld repair area plus a minimum of 3 in (76 mm) on either side of the weld area, to a minimum of 1100 °F (594 °C), but not exceeding 1300 °F (704 °C);

w) Immediately cover the weld repair area with a cooling cover, box, or heat blanket to allow slow cooling of the weld area:

i. Protect the weld area from the elements.

x) Allow the weld repair area to cool below 400 °F (204 °C) before starting the finish grinding;

y) Finish grind and slot to the proper dimension's slopes, angles, and radii for the component being welded. (i.e. remove the words "the casting");

z) Use a straight edge and required gauges to check that the finish grind is with tolerance;

aa) Inspect all repairs within 1-week of repair and regrind and slot as required;

7.3 Engine Wheel Burn Repair

7.3.1 Engine wheel burns appear as an oval or round shape, having a blue or dark gray colour on the running surface of the rail where locomotive wheels have slipped or spun. This slippage causes a rapid heating and cooling effect on the carbon steel rail, causing surface and sub-surface martensite. There are usually several marks on each rail. Sometimes this will be seen on both rails with spacing corresponding to locomotive wheels.

7.3.2 Engine wheel burns can be repaired only:

a) On Class 1 Yard Track;

b) Using the electric arc welding process (FCAW or SMAW), as outlined in Section 7.2, subject to the following limits:

i. In wood tie territory, repair only engine wheel burns that are 10 in (254 mm) or less in length, and 3/8 in (10 mm) or less in depth as measured after grinding;

ii. In concrete tie territory, repair only engine wheel burns that are 1/8 in (3 mm) or less in depth, as measured after grinding;

iii. The method of measurement must be made using a straight edge and taper gauge for depth, and a tape measure for length.

7.3.3 Inspect before welding, the 3 ties on each side of the weld repair area. Determine if the rail can expand during the repair. Nip spikes or remove fasteners and remove anchors as necessary.

7.3.4 Shim rail up with a crown of 1/8 in (3 mm) at the centre of the engine burn repair area as measured using a 36 in (914 mm) straight edge and taper gauge.

7.3.5 Don't allow trains, locomotives, rail cars, or heavy track units, on or over any engine wheel repair weld until:

a) The repair area has been finished ground;

b) The repair area has cooled to below 400 °F (204 °C).

c) ***Note:*** Post-heating of the rail base may be required to prevent the weld area from dipping.

7.3.6 Follow all required welding procedures for welding carbon steel rail as outlined in Section 7.2.

7.3.7 Ensure that after welding, the three (3) ties on either side of the weld repair area:

a) Have the pre crown shims removed;

b) Are firmly tamped;

c) Have spikes or fasteners applied (plugged or glued) per the required pattern for Class of Track.

7.4 Switch Point (SP) Welding

7.4.1 Switch points can be repaired only:

a) On Class 1 Yard Track, and

b) Using the procedures set out in Section 7.2 above.

7.4.2 If using the Shielded Metal Arc Welding (SMAW) method using stick electrode, then:

a) Due to the narrow build-up area towards the tip of the switch point, use the following smaller diameter electrodes:

i. 1/8 in (3 mm); or

ii. 5/32 in (4.0 mm).

b) Use stringer beads not exceeding 5/8 in (16 mm) in width, for both the FCAW and SMAW process.

7.4.3 Don't weld repair switch points:

a) On any track with speeds greater than Class 1. This includes:

i. The diverging route switch points going into Class 1 Track from the main track or

ii. Where the through track speeds are Class 2 and above.

b) Where the switch point defect area to be repaired is 12 in (305 mm) long or greater;

c) Where the switch point repair area is greater than 4 in (100 mm), the switch point must only be repaired once;

d) *Note:* There are no restrictions on the number of times a switch point can be weld repaired when the repair length is less than 4 in (100 mm).

e) Within 200 ft (61 m) of any bridge structure.

7.4.4 Any switch point intended to be welded in a signalled territory must be supported with a signals work plan methodology approved by the Metrolinx E&AM – Track and E&AM – Signals and Communications:

a) Notify the S&C Maintainer prior to welding any switch point.

7.4.5 Remove all defective material by grinding only.

7.4.6 Do not allow any movements over or on any switch point during weld repair.

a) Use a copper backing plate between the switch point and stock rail during the weld build-up process. See Figure 7-8.

Figure 7-8: Photo of a Copper Backing Plate Between Switch Point and Stock Rail
Courtesy CN Training

7.4.7 Finish-grind all switch point weld repairs:

a) To match and conform to the switch point rail profile, slope angles, and radii;

b) So that the switch point fits tightly against the stock rail.

7.4.8 Don't allow trains, locomotives, rail cars, or heavy track units, on or over any switch point weld repair until:

a) The repair area has cooled below 400 °F (204 °C);

b) The repair area has been ground as per Item 7.4.7 above;

c) The switch point has been adjusted to fit stock rail, and

d) All switch plates have been cleaned and lubricated.

7.4.9 If in signalled territory, the S&C Maintainer must inspect, and make necessary adjustments prior to restoring to service.

7.5 Rail End Build-Up

7.5.1 Rail joint repair in CWR on main track is typically completed by thermite or electric flash butt welding. There are occasions where mismatched rail ends or battered joints require weld buildup or repair to comply with the operating speed for that Class of Track.

7.5.2 Don't repair rail ends or joints at glued insulated joints (IJ), regardless of track.

7.5.3 In Class 3 Track and above, don't weld repair beyond the last bolt hole of the joint.

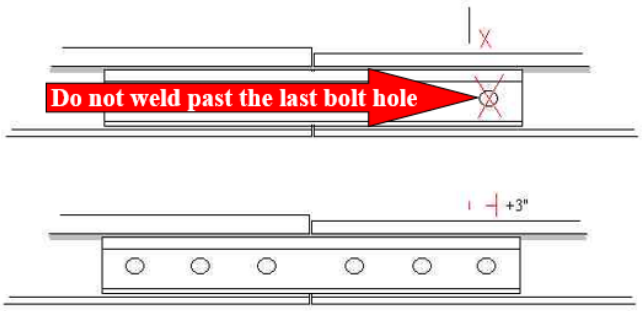


Figure 7-9: Limits of Rail End Weld Build-up

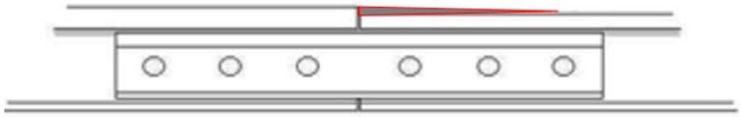


Figure 7-10: Example of Rail End Build-up within Acceptable Limits

7.5.4 Any rail ends or joints, intended to be welded in signalled territory, must be supported with a signals work plan methodology approved by Metrolinx or its designate.

a) Notify and seek the permission of the S&C Maintainer, prior to the application of rail bypass cables or temporary bond wires.

b) Only employees who have been trained in the application of bonding and rail repair may install temporary bond wires.

c) Remove rail bonds by grinding prior to welding rail ends or joints.

d) Don't use or install rail bypass cables and temporary bond wires:

i. Around insulated joints;

ii. Within the limits of the outer opposing signals of a control point (OS Circuit);

iii. Within interlocking limits;

iv. Across the track from one rail to the other; and

v. For the purpose of circumventing normal signal operations.

7.5.5 Weld only with the S&C Maintainer on hand, and with a signals work plan methodology in place and approved by Metrolinx or its designate.

a) Non-glued insulated joints can be welded by removing the joint bars and installing standard splice bars, welding only one side of the joint at a time.

7.5.6 After completing the welding process, finish grinding and slotting, and allow the welded joint to cool to below 250 °F (121 °C) or in accordance with the manufacturer's requirements, before re-applying the non-glued insulated joint bars.

7.5.7 Inspect the joint to be repaired:

a) Ensure that the rail joint assembly is intact and secure;

b) Replace broken or cracked splice bars, missing or damaged bolts, nuts, washers, tie plates or spikes;

c) Ensure that there is one non-defective tie within 18 in (457 mm) of the centreline of the joint;

d) Ensure that the joint ties are properly tamped.

7.5.8 Visually inspect for cracked or broken rails before and after welding. If suspected, remove the splice bars and dye penetrant test.

7.5.9 Remove all bond wires near the weld repair area by grinding. Ensure that all copper or brass is removed. **Do not use a chisel**.

7.5.10 Follow the welding procedures set out in Section 7.2 above.

7.5.11 If the welding operation is interrupted for any reason, then:

a) Remove by grinding any work-hardened material that may have formed;

b) Reheat the weld area to the proper welding temperature prior to resuming welding.

7.5.12 Ensure that all finish grinding and slotting of the weld repairs match and conform to the profiles, slope angles, and radii of the rail.

7.5.13 Grind rail joints flat within a tolerance of 0.00 in low to +0.015 in high.

7.5.14 Finish-grind all weld repairs at rail end mismatches, with a uniform slope over a minimum distance of 12 in (305 mm) in Class 3 Track and above.

7.5.15 Slot all weld repaired rail joints so as to be below the weld repair.

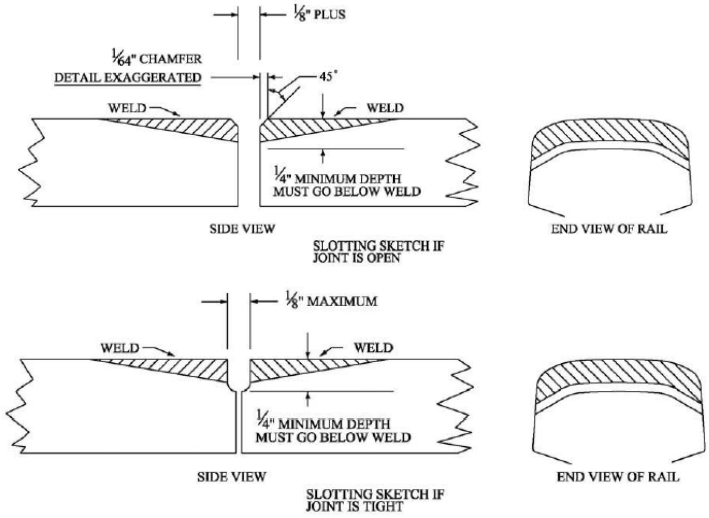


Figure 7-11: Slotting of Rail Ends

7.5.16 Do not slot cut into joint bars.

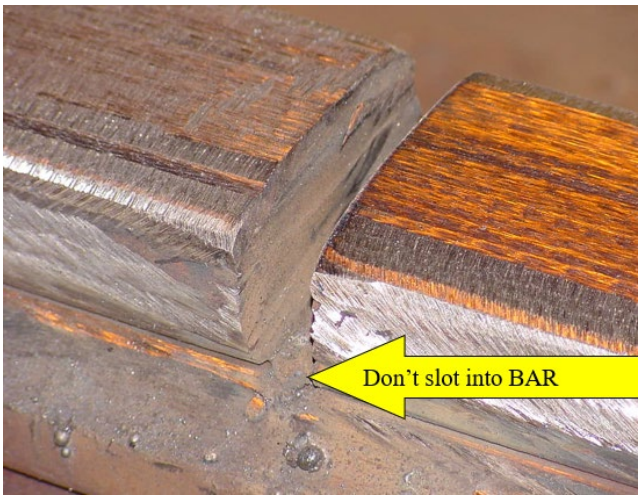


Figure 7-12: Photo of Slotted Weld Repaired Joint
Courtesy CN Training

7.5.17 Notify the S&C Maintainer, after completion of the repair, of the need for bonding of the repaired joint and removing any temporary bond wires or bypass cables used.

a) Only the S&C Maintainer or designate can remove temporary bonds or bypass cables to ensure that the signal system is in compliance and in proper working order.

b) Any joint or rail end that has been repaired by the electric arc welding process and is intended to be thermite or electric flash butt welded, must have the entire electric arc weld repair plus 4 in (100 mm) beyond that removed by saw cutting.

7.6 Inspection Prior To Repair Welding of Frogs and Diamond Crossings.

7.6.1 Perform the following inspections when repairing frogs or diamond crossings:

a) Identify metal flow or bulging areas in the flangeway walls;

b) Inspect for marks, chips, spalling, or cracks;

c) Inspect for any type of rail breaks, bolt hole cracks, head web separations, or vertical or horizontal split heads. If found, the frog or diamond crossing cannot be welded;

d) Inspect for offsets in the wheel running surfaces (including all mating surfaces);

e) Check the following for excessive metal flow:

i. Joints at heel and toes of frogs or diamond crossings;

ii. Heel of manganese inserts;

iii. Mating surfaces between all running rails, including long and short points, and wing rails.

f) Check for missing, damaged, or loose bolts, nuts and washers. Replace, renew, or tighten bolts as necessary before welding;

7.6.2 Inspect the condition of the following:

a) Gauge and alignment of the frog or diamond crossing;

b) Welds on frog and crossing plates, plate stops, blocks, elastic fasteners shoulders, etc.;

c) Broken or missing plates and fasteners.

7.6.3 Inspect for surface, tie, and subgrade conditions;

7.6.4 Check the frog guard check gauge and guard face gauge to ensure compliance with Transport Canada Rules Respecting Track Safety and Metrolinx Track Standards (formerly GTTS Section 17).

7.7 Welding Procedures for Carbon Steel Rail in Frogs and Diamond Crossings

7.7.1 If any part of the work area is out of compliance for the Class of Track, the speed restriction is 10 mph (16 km/h) or out of service.

7.7.2 If it has not been marked indicating a rail defect, follow the welding procedures outlined in Section 7.2.

7.7.3 Start and finish one section at a time. For example, weld the point, wing, heel and toe joints, or tread wear, separately. This will help maintain heat input while welding.

7.7.4 Use flangeway blocks while building up flange walls on carbon steel rail frog wing and point areas, and diamond crossings. Only copper blocks or guides are acceptable.

7.7.5 If the welding operation is interrupted:

a) Grind all flangeway openings to 1 7/8 in (47 mm) prior to any train movements;

b) Ensure the proper speed restriction is in place to protect movement. The maximum speed over a frog or diamond is 10 mph before grinding is complete;

c) Regrind any work-hardened areas;

d) Reheat the weld area to the proper welding temperature prior to resuming welding.

7.7.6 Ensure that all finish grinding and slotting of the weld repairs match and conform to the slope angles and radii of the rail profile.

7.7.7 *Note:* All finish grinding tolerances for frogs and diamond crossings can be found in Section 6.

7.8 Carbon Steel Rail Components That Cannot Be Repair Welded

7.8.1 The following carbon steel rails must not be repair welded:

a) The point or wing rails on movable point frogs;

b) The spring wing rail on spring frogs;

c) The wing rails abutting a manganese insert on RBM frogs and diamond crossings;

d) Any carbon steel rail that cannot be properly preheated or post heated.

7.8.2 The main line running rail through any flange bearing, or one-way low speed (OWLS) frog or flange bearing diamond crossing may develop a groove from wheel flanges. This groove cannot be repaired by welding.

7.9 Electric Arc Welding Consumables

7.9.1 All welding consumables must meet manufacturer's specifications for size and type of material being repaired.

7.9.2 All manufacturer's welding parameters must be followed for the product being used. For polarity, amperage ranges, etc., consult the labels found on boxes or containers.

Exception: Water cooling of welds is not allowed. Air cooling is the recommended method.

7.9.3 Welders must have knowledge and understanding of manufacturer's Material Safety Data Sheet (MSDS) for product being used.

7.9.4 Manganese welding consumables must be:

a) an austenitic manganese steel filler metal classified in accordance with CWB or AWS; or

b) previously, by brand name, rather than a CWB/AWS classification.

7.9.5 Approved welding consumables for manganese components:

a) Flux Cored Arc Welding (FCAW) wire is the recommended method for build-up repairs of manganese components;

b) The maximum electrode diameter allowed for use on any manganese component is 3/16 in (5 mm).

Table 7-1: Approved Welding Electrodes or Wire for Manganese Steel Repair

Name	Type	Size	Polarity	Use
Track Weld Frog Build 575M	(FC) Wire	5/64″ (1.98 mm)	Reverse DCEP +	Build up manganese components.
Track Weld Frog Build 575M	(SM) Electrode	3/16″ (4.76 mm)		
Track Weld 912	(SM) Electrode	3/16″ (4.76 mm) 5/32″ (3.9 mm)	Reverse DCEP +	Repair of manganese casting flangeway cracks and defects. Must be kept 1″ (25mm) below running surface.
Matweld 900	(SM) Electrode	3/16″ (4.76 mm)		

Name	Type	Size	Polarity	Use
Eutectic ManTrak 2N	(FC) Wire	5/64″ (1.98 mm)	Reverse DCEP +	Build up manganese components.
Eutectic ManTrak 1N	(SM) Electrode	3/16″ (4.76 mm) 5/32″ (3.9 mm)		
Inweld Canada HABCO Frogspec – 0	(FC) Wire	5/64″ (1.98 mm)	Reverse DCEP +	Build up manganese components.
Inweld Canada HABCO Frogspec – 0	(SM) Electrode	3/16″ (4.76 mm)		
Inweld Canada HABCO Frogseal	(SM) Electrode	5/32″ (3.9 mm)	Reverse DCEP +	Repair of manganese casting flangeway cracks and defects. Must be kept 1″ (25mm) below running surface.
Inweld Canada HABCO Frogseal	(SM) Electrode	3/16″ (4.76 mm)		
Lincoln Frogmang	(FC) Wire	5/64″ (1.98 mm)	Reverse DCEP +	Build up manganese components.
Lincoln Frogmang	(SM) Electrode	3/16″ (4.76 mm)		

7.9.6 Approved welding consumables for carbon steel rail and rail components:

a) Carbon steel rail welding consumables must be:

i. a steel filler metal classified in accordance with CWB or AWS;

ii. or previously by brand name, rather than a CWB/AWS classification.

Table 7-2: Approved Welding Electrodes or Wire for Repair of Carbon Steel Rails

Name	Type	Size	Polarity	Use
Track Weld Rail Build 540	(FC) Wire	5/64″ (1.98 mm)	Reverse DCEP +	Build up repair Carbon Steel Rail and Components. Small diameter electrodes for switch point repairs.
Track Weld Rail Build 540	(SM) Electrode	1/4″ (6.3 mm) 3/16″ (4.76 mm) 5/23″ (3.9 mm) 1/8″ (3.1 mm)	Reverse DCEP +	
Eutectic TufTrack 2	(FC) Wire	5/64″ (1.98 mm)	Reverse DCEP +	
Eutectic TufTrack 4	(SM) Electrode	1/4″ (6.3 mm) 3/16″ (4.76 mm) 5/23″ (3.9 mm) 1/8″ (3.1 mm)	Reverse DCEP +	
Inweld Canada HABCO Railspec – 0	(FC) Wire	5/64″ (1.98 mm)	Reverse DCEP +	
Inweld Canada HABCO Railspec – 0	(SM) Electrode	1/4″ (6.3 mm) 3/16″ (4.76 mm) 5/23″ (3.9 mm) 1/8″ (3.1 mm)	Reverse DCEP +	

b) Other SMAW electrodes for various uses:

Table 7-3: Approved Welding Electrodes for Repair of Plain Carbon Steel

Name	Type	Size	Polarity	Use
CWB/AWS 7018-9018	(SM) Electrode	3/16" (4.76 mm) 5/23" (3.9 mm) 1/8" (3.1 mm)	Reverse DCEP +	Repair welding of structural steel, clips, braces, stops, etc.

c) Metal removal, cutting, and gouging electrodes:

i. Carbon arc-air electrodes are never to be used on any carbon steel rail or rail components.

Table 7-4: Approved Electrodes for Carbon Arc Air Cutting or Gouging

Name	Type	Size	Polarity	Use
Inweld Canada HABCO MX 221	Copper Coated Carbon Arc-Air Electrodes	Various Sizes: Flat or Round	Straight DCEN -	For removal of cracked or damaged material in manganese castings, and gouging out welds on clips, braces, and stops, etc.
Arc - Air	Copper Coated Carbon Arc-Air Electrodes	Various Sizes: Flat or Round	Straight DCEN -	

8 Cutting of Rail

8.1 General

8.1.1 Only those persons who have been trained and certified are allowed to saw or torch cut rail.

8.1.2 Saw or torch cutting is considered Hot Work, and all safety, fire risk, and PPE requirements must be followed.

8.1.3 The approved method for cutting rail is with an abrasive saw blade designed specifically for cutting rail:

a) The RPM rating must be matched to the type of power source being used;

8.1.4 Prior to cutting any in-track rail, reference marks must made on the field side web of the rail. The distance between the marks must be measured and noted on the rail prior to the cut being made. This will create a reference to confirm whether any rail was added or removed during the repair. See the Metrolinx Track Standards (formerly GTTS) for additional instructions.

8.1.5 Prior to cutting any rail in signal track territory, the work must be supported with a signals work plan methodology approved by the Metrolinx E&AM – Track and E&AM – Signals and Communications.

8.2 Saw Cutting

8.2.1 All rail ends must be saw cut:

a) The saw cut must be square and perpendicular to the longitudinal axis of the rail, with a variation not exceeding 1/8 in (3 mm), and all burrs and sharp edges must be removed;

b) When saw cutting rail for re-use, cut a minimum of 4 in (100 mm) beyond any of the following so as to remove them completely from the rail being reused:

i. Thermite welds;

ii. Flash butt welds;

iii. Torch cuts; and

iv. Pin brazing or CAD bonds.

c) Most cut rails in track are intended to be welded, so cut placement is critical. Placement of saw cuts must be as follows:

i. Placed in the centre of the tie crib, no closer than 4 in (100 mm) from the edge of a tie;

ii. A minimum of 4 in (100 mm) away from the nearest edge of any hole, bolt or bond pin

d) All rail that is saw cut must have the exposed ends tested for longitudinal defects with dye penetrant, this includes rail currently in track.

e) **Exception:** New rail does not need to be dye penetrant tested.

8.3 Torch Cutting

8.3.1 In cases of emergency, torch cutting of the rail is permitted.

a) Prior to use of all torch cutting equipment and preparing to cut the rail, ensure the following:

i. Equipment has been inspected and leak tested;

ii. A fire risk assessment has been performed, and proper firefighting equipment is laid out and is ready for use;

iii. Wet down the area, if needed;

iv. All spark shields or guards are in place;

v. A Fire Watch has been assigned;

vi. Use proper body position to keep yourself and coworkers clear of flying sparks or slag;

vii. Never straddle the rail while destressing or relieving pressure;

viii. Secure the rail if needed; and

ix. Never stand in front or behind bolts being cut, keeping your body out of the line of fire.

b) Inspect rail with torch cut ends for signs of visible cracking prior to saw cutting. If cracking is noted, make the saw cut 4 in (100 mm) beyond the visible crack.

8.3.2 **Safety Critical Rule:** All torch cuts must have a minimum of 4 in (100 mm) of rail removed from each side of the torch cut by a rail saw. The 4 in (100 mm) is measured from the nearest edge of crooked cuts or torch nicks.

a) **Exception:** If the torch cut rail is to be immediately welded.

i. The torch cut rail end must be trimmed with a rail saw, removing a minimum of ¼ in (6 mm) within 30 minutes of the torch cut;

ii. The saw cut face rail sliver must be DP tested. The torch cut sliver must be allowed to cool prior to dye penetrant testing.

iii. All saw cut ends must be dye penetrant tested.

8.3.3 The "**H**" cut is the preferred torch cutting method to destress rail under compression. Follow these steps to make an "H" cut:

a) Ensure that the rail or joint is properly referenced and marked prior to cutting;

b) If destressing and adding a plug rail, ensure that the reference marks are outside of the plug rail being installed (follow the Metrolinx Track Standards (formerly GTTS) requirements);

c) Ensure the rail is cut as close as possible to the centre of the tie crib;

d) Clear the ballast from under the rail, creating a pocket for slag;

e) Lay out the cut marks on the top of the rail head and both sides of the rail base, using a paint marker and a square or straight edge. See Figure 8-1 below;

Figure 8-1: Marking the Rail for Torch Cutting

f) Make the marks as straight and square as possible. The marks should be between 1 and 2 in (25 to 50 mm) apart;

g) Use these cut marks as the location where to cut the rail;

h) Make two vertical cuts across the rail head down to the head web fillet radius;

i) Cut horizontally between the vertical cuts at the bottom of the head web fillet to remove the head of the rail. See Figure 8-2 below;

Figure 8-2: Torch Cutting the Head and Base

j) Clean the slag and spatter from the web and base, using a chipping hammer and wire brush, in preparation for the next cut. Never use a gloved hand or the back of the cutting torch;

k) On the gauge side, cut from the outside of the base towards the web-base fillet, then across the web-base fillet and back to the outside of the base. Remove this piece of rail base. See Figure 8-2 above;

l) Repeat the above step for the field side base cut;

m) Start at the top of the web and cut in a downward direction using a weave pattern approximately 1/2 in (12 mm) wide. See Figure 8-3 below;

n) ***Note:*** Remember, the rail is in compression and will push together (inwards), so starting at the top of the web will help force the rail downwards.

Figure 8-3: Cutting the Web with a Weave Pattern

o) Repeat the above steps if necessary, cutting the web top to bottom numerous times until the rail stops pushing inwards. This may require widening the rail head and base cuts;

p) Loosen or adjust rail anchors to achieve the proper rail temperature adjustments;

q) Saw cut the rail to the proper distance, once the rail has stopped pushing inwards and the rail is in proper adjustment;

r) Saw cuts must be a minimum of 4 in (101 mm) away from the nearest edge of the torch cut unless the rail is to be thermite welded within 30 minutes, otherwise, be prepared to cut in a plug rail to compensate for the rail gap and rail removed;

s) Dye penetrant test the saw cut end. If cutting a weld gap, use the saw cut rail sliver for dye penetrant testing, as it is the mirror image of the in-track rail; and

t) Torch cutting on any manganese casting of any track component is prohibited because of overheating the manganese casting above 500 °F (260 °C), destroying the grain structure.

8.3.4 Torch cutting of defective material from carbon steel rail that is intended to be repaired by the electric welding processes (FCAW-wire or SMAW-stick electrode) is prohibited. Examples of repairs where such torch cutting is prohibited are:

a) Engine wheel burns, slips, or fractures;

b) Switch points;

c) Rail end build-up due to height mismatch; and

d) Rail end build-up due to batter.

9 Dye Penetrant Test

9.1 Testing Procedure

9.1.1 All rail that is saw cut, except new rail, must have the exposed ends tested for horizontal and longitudinal defects with Dye Penetrant (DP).

9.1.2 Follow this procedure when performing a dye penetrant test:

a) Inspect the dye penetrant kit to ensure that it contains the following: cleaning solvent, dye penetrant spray and developing spray;

b) Keep a supply of clean rags handy;

Figure 9-1: Dye Penetrant Kit

c) Spray the saw cut face with solvent and wipe off with a clean rag;

d) Spray dye penetrant to the cut face of the rail and let stand for a minimum of 5 minutes;

e) Wipe dye penetrant off with a clean rag;

f) Shake developer for approximately 1 minute, then spray the face of the rail and let dry;

g) Watch for red lines or spots showing through the white developer, which will indicate defects;

h) ***Note:*** In colder temperatures, this might take longer to occur;

Figure 9-2: DP Tested Rail with a Horizontal Split Web Defect in the Head-Web Intersection

i) Keep the dye penetrant kit warm during cold weather. Never allow the kit to freeze;

j) Mark the rail "DP" in lettering 2 in (50.8 mm) high, using a white paint marker on the web at each end tested;

k) Rail installed which has not been dye penetrant tested must be speed restricted to Class 1 Track until:

   i. Dye penetrant testing has been completed, or

   ii. The rail is ultrasonically inspected.

l) ***Note***: If cutting a weld gap, the rail sliver must be dye penetrant tested, as the saw cut rail sliver is the mirror image of the in-track rail, and if a defect exists, it will also exist in the sliver.

10 Thermite Welding

10.1 Overview

10.1.1 Thermite welding is a process that employs molten metal to permanently join rail. The process employs an exothermic reaction of a thermite composition to heat the metal, and requires no external source of heat or current. The chemical reaction that produces the heat is an aluminothermic reaction between aluminum powder and metal oxide.

10.1.2 All aspects of thermite welding are considered "Hot Work" which means any work involving a source of ignition, such as grinding, cutting of rail, thermite welding, welding, etc. These activities must include a fire prevention and response plan, including completion of a site-specific Right-of-Way and Bridge Fire Risk Assessment, Mitigation and Emergency Response.

10.1.3 **Safety critical rule:** The molten steel can reach temperatures exceeding 3000 °F (1649 °C). Before igniting the charge, ensure everyone (except for the person performing the ignition) is clear of the weld area by at least 40 ft (12.2 m), and remains in the clear for at least 1 minute after the pour is complete.

10.1.4 Only those Welders who are trained and certified in the specific welding process (Pandrol or Orgo-Thermit) are allowed to make welds on Metrolinx property.

10.2 Thermite Welding on Bridges

10.2.1 Welders working on bridges, scaffolds, platforms, and other such work areas higher than the surrounding ground must comply with all Metrolinx and TC *Fall Protection Guidelines* and other governmental regulations in the use of lifelines, safety belts, or other safeguards as protection against falling.

10.2.2 Rails which require thermite welding on bridges must be welded off the bridge and then laid in place on the bridge after all work on the weld is finished. However, when there is no alternative to doing thermite welding on a bridge, the following precautions must be taken:

a) Contact the Maintenance Delivery – Manager of Bridges and Structures and the Maintenance Delivery – Manager of Track to ensure they are aware of and authorize the work plan methodology describing the work, risks, and mitigations required to perform the work;

b) Perform a site inspection to identify any hazards, and in particular, anything that may take fire;

c) Examine the entire structure. Do not assume that if no combustible materials are visible from above, the bridge is fire-safe. A ballast deck timber trestle is just as combustible as an open deck timber trestle and must be treated as such;

d) Remove any loose combustible material, dry vegetation, etc.;

e) When thermite welding must be performed on open deck bridges, use a ¼ in (6mm) thick steel sandbox partially filled with sand and placed between the ties in case of a run-through. See Figure 10-1 below;

f) Arrange for the bridge timbers to be spread by the Maintenance Delivery - Bridges and Structures resources so that the box can be installed. Do not undertake any welding without the use of this box;

g) Complete a site-specific Right-of-Way and Bridge Fire Risk Assessment, Mitigation and Emergency Response;

h) Conduct a thorough job briefing with all personnel involved. Advise what must be done in case of accident or fire;

i) Do not attempt any welding when insufficient personnel and equipment are available to take care of any accident or fire that may occur;

j) Assign a designated Fire Watch person(s) and ensure that such person(s) understand their duties;

k) Ensure that suitable firefighting equipment is in position before the work commences;

l) Ensure that Fire Watch person(s), wherever positioned (on or under the bridge), have access to the firefighting equipment;

m) The wood ties, wooden back walls and bridge timbers, plus the area around the structure, must be wetted with water with a fire retarding foam additive to lessen the chance of fire from hot work activities;

n) The Fire Watch person(s) must remain at the site for a minimum of 2 hours after all hot work has been completed.

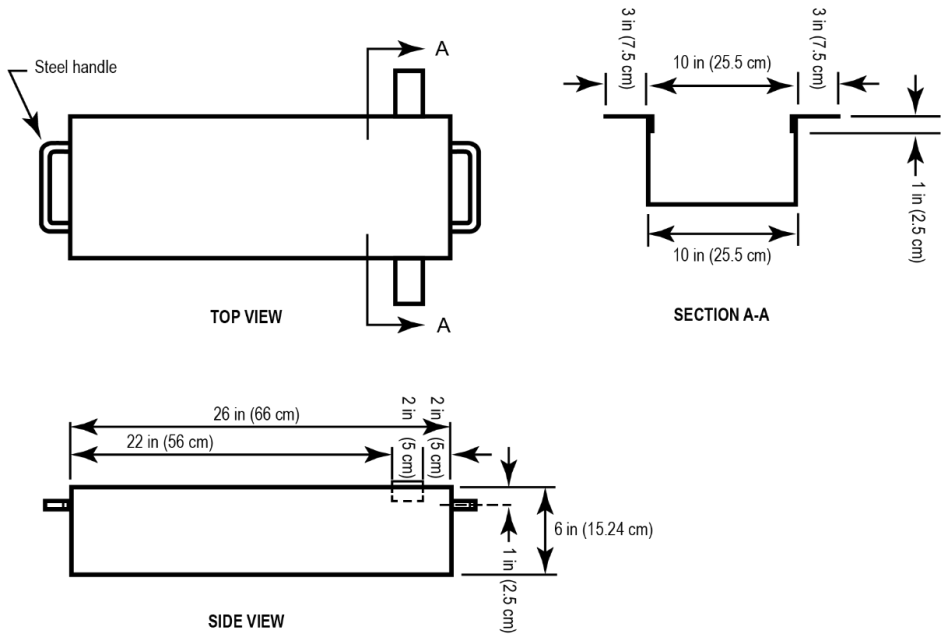


Figure 10-1: Thermite Welding Safety Plan

10.3 Cold Weather Restrictions for Thermite Welding

10.3.1 Hot thermite weld material has the potential to become explosive whenever it comes in contact with moisture. The source of moisture may be in the form of rain, snow and/or frost in the ballast. Follow Metrolinx and the manufacturers' procedures for welding in all conditions. In addition, take the following precautions when thermite welding in the presence of rain, snow and/or frost:

a) Thermite welds are recommended to be performed in dry weather conditions;

b) Thermite weld in light moisture conditions, if and only if, the weld area, welding material (charge, moulds, crucible, and waste material), and the finished weld can be protected from moisture. The use of a welding umbrella or other device must be used in such cases;

c) Suspend welding operations if the weld area cannot be protected from moisture;

d) Do not thermite weld in heavy moisture conditions such as rain, sleet, or blowing snow;

10.3.2 Follow the preheating and slow cooling requirements for working in adverse weather conditions, identified in the table below:

Table 10-1: Preheating and Cooling Requirements According to Rail Temperature

Rail Temperature and Weather Condition	Mitigation
Above 40 °F (5 °C) and Clear Weather	Air cool normally. A weld cooling cover is not required.
Above 40 °F (5 °C) with Wind, Rain, Sleet, or Snow	Apply weld cooling cover immediately after shearing. (Moving risers down to allow for grinder clearance is permitted, care must be taken not to break off or remove.) Leave cover/blanket in place until the weld has cooled below 900 °F (483 °C). (This is approximately 20-25 minutes after the pour.)
Between 40 °F (5 °C) and 5 °F (-15 °C)	Prior to the application of the moulds, preheat the rail head web and base to a temperature of 100 °F (37 °C) for a distance of 36 in (76 mm) on both sides of weld gap. Complete weld and de-mould normally. Apply weld cooling cover immediately after shearing. (Moving risers down to allow for grinder clearance is permitted, care must be taken not to break off or remove.) Leave cover/blanket in place until the weld has cooled below 900 °F (483 °C). (This is approximately 20-25 minutes after the pour.)
Below 5 °F (-15 °C)	No thermite welding is permitted.

10.3.3 It is the Welder's responsibility to determine if thermite welding can be performed safely during adverse weather conditions;

10.3.4 The following list of precautions must be followed in Cold Weather conditions as defined in the Metrolinx Track Standards (formerly GTTS):

a) Clear a minimum of a 10 ft (3 m) radius of snow from around the weld area. When this is not practical due to embankment constraints, clear the snow to at least the edge of the ballast section, along with clear a walkway to the waste disposal area;

b) Use a hydraulic rail puller on all closure welds:

i. Remove the rail pullers only when the weld has cooled to below 700 °F (371 °C). This applies in all conditions;

c) Install an approved drip pan with dry sand under the weld area to prevent any excess molten metal from contacting any moisture that may be present;

d) Heat the ballast with a torch in order to remove any moisture from the ballast;

e) Adhere to all preheat and tear-down times. A minimum of 5 minutes is required after the pour is completed before the removal of slag pans, crucible, and normal demoulding begins. This applies in all conditions;

f) Place the slag pan/basin on a dry, level surface and allow to cool for a minimum of 15 minutes after the pour is completed, before being emptied;

g) Secure a dry location to place all waste material. Use a fireproof steel box, drum, or rack on the back of a truck for disposal of the weld waste. This applies in all conditions.

i. Dispose of all welding material, slag, used crucibles and moulds in a fireproof steel box, drum, or rack on the back of a truck and remove from Metrolinx property for environmental disposal. Such material is never to be left on or buried along the Right of Way.

10.4 Rail Wear Restrictions for Thermite Welding

10.4.1 Comply with the Metrolinx Track Standards (formerly GTTS) Rail Wear Limits for rail to be thermite welded.

10.4.2 Use a rail wear gauge to correctly measure vertical and gauge face offset differentials.

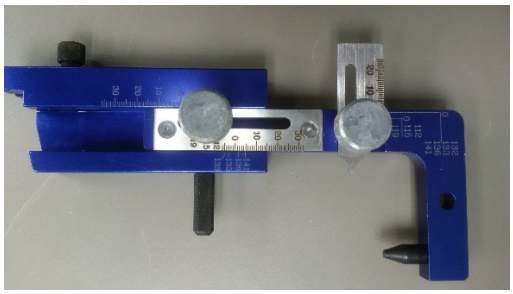


Figure 10-2: Rail Wear Gauge

10.4.3 There are limits to the acceptable difference in the height of the two rail ends:

a) All rail height offsets must be taken at the base;

b) The difference in the height of the rail heads cannot exceed 3/16 in (5 mm);

c) If the difference is greater than 1/8 in (3 mm) but less than 3/16 in (5 mm), use the appropriate step joints or new to worn kit; and

d) Rails with greater than 3/16 in (5 mm) vertical offset must have a transition rail cut to match vertical offset rail wear.

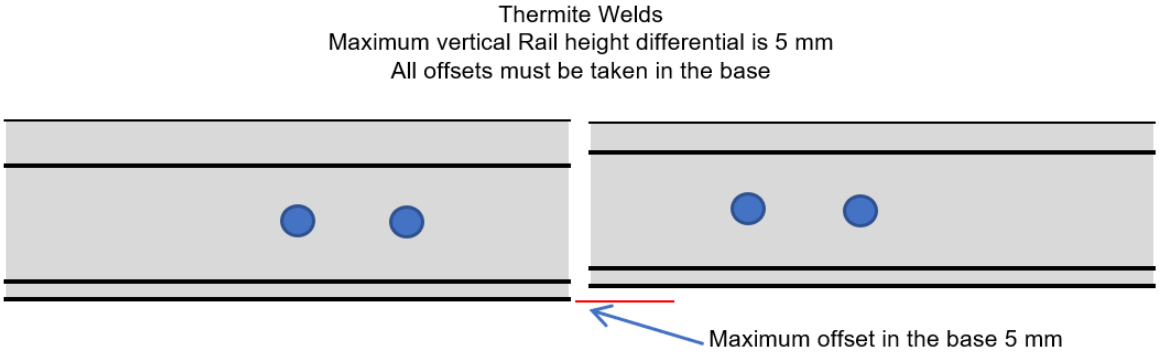


Figure 10-3: Handling Rail Height Offsets

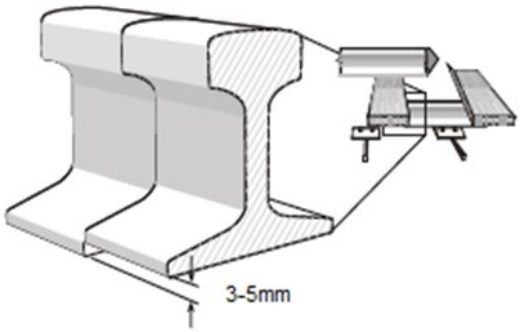


Table 10-2: Maximum Allowable Vertical Rail Base Offsets

Maximum Allowable Vertical Rail Base Offset			
Thermite Welds	**100 ARA or smaller**	**115 RE**	**132 RE/136 RE**
Straight/standard thermite kit or kit with equal wear	**Up to 1/8 in (3 mm)**	**Up to 1/8 in (3 mm)**	**Up to 1/8 in (3 mm)**
Greater than 1/8 in (3 mm) up to 3/16 in (5 mm) Vertical Offset			
If vertical base offset exceeds 1/8 in (3 mm), a sloped base plate must be used	**Not allowed**	**1/8 in (3 mm) to 3/16 in (5 mm)**	**1/8 in (3 mm) to 3/16 in (5 mm)**
Rails with Greater than 3/16 in (5 mm) Vertical Offset must have transition rail cut to match vertical offset rail wear.			

10.4.1 The use of compromise thermite weld kits on Metrolinx-owned tracks is not allowed.

10.4.2 Gauge face wear must be matched as close as possible:

a) The greater the gauge face wear difference, the greater possibility of a run out/leak;

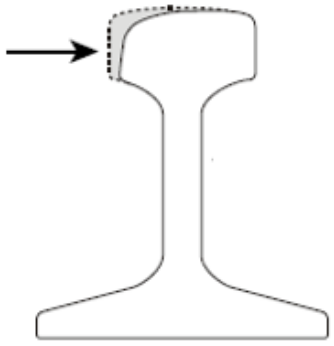


Figure 10-4: Differences in Gauge Face Wear

b) When finishing grinding, all tapers must be transition ground to match existing rail contours (3 mm of height transition in 42 inches of length).

10.4.3 Caution must be taken when welding 136 lb (61.5 kg) thick web rail to 136 lb (61.5 kg) RE rail:

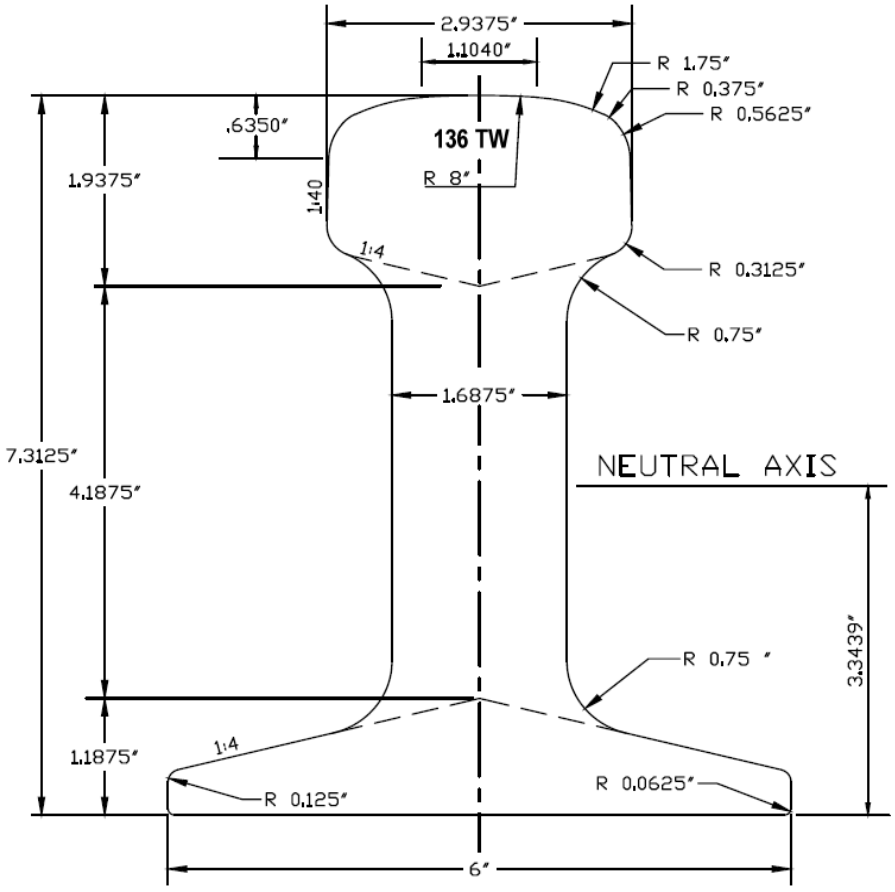


Figure 10-5: Cross Section of Thick Web Rail

a) Only the joint area of a 136 lb (61.5 kg) thick web rail that has been machined to match the web of a 136 lb (61.5 kg) rail to accommodate joint bars can be welded;

Figure 10-6: Machined Thick Web Rail to Match Standard Web

b) Care must be taken to ensure proper mould fit on machined areas of the thick web rail to standard web. Mould filing may be required.

10.5 The Critical Steps of Thermite Welding

There are situations where rail conditions, different types of metallurgy, or even the temperature will require variations in the standard welding procedures.

A successful thermite weld can be seen as separate steps that must be completed in a specific sequence:

10.5.1 **Job preparation:**

a) Use standard checklists to ensure that all the necessary tools, materials, equipment, and information are available before leaving for the weld site:

i. Consumables checklist;

ii. Hardware checklist;

iii. Pre & post-heating equipment;

iv. Safety equipment checklist;

v. Power tools checklist;

vi. Hand tools checklist;

vii. Measurement tools checklist; and

viii. Information checklist with forms and documents.

10.5.2 **Site preparation:**

a) This step must be completed before starting any work or removing tools from the welding truck;

b) Evaluate the general condition of the site;

   i. Check for safety hazards;

   ii. Check for fire hazards;

   iii. Make sure the area immediately near the weld and the steel box is free of any form of moisture; and

   iv. Check for underground cables before digging.

c) Correct any situations which create a potential fire or safety hazard;

d) Determine if the weather suitable for welding and if the weld area will need protection with an umbrella or tent;

e) Joints intended to be welded in signalled territory must be supported with a signals work plan methodology approved by Metrolinx or its designate. Ensure that this is in place;

f) Remember that in signalled territory, temporary rail jumpers or cross-bonds must be installed prior to commencing joint removal;

g) S&C Maintainer must be notified prior to the application of rail bypass cables or temporary bond wires; and

h) Only Track, Welding, S&C and other employees, trained in the application of bonding and rail repair may install temporary rail bonds.

10.5.3 **Track preparation:**

a) Verify line and surface;

b) Place a thermometer on rail or check rail temperature;

c) Ensure rail type, weight, and wear is compatible with weld kit. The vertical offset must not exceed 3/16 in (5 mm);

d) Verify the weld gap is no closer than 4 in (102 mm) from tie;

e) Verify that field welds must not be made:

   i. Within 6 ft (1.8 m) of a thermite weld;

   ii. Within 3 ft (914 mm) of a flash butt weld.

f) Look for any joint or rail ends that have been repaired by the electric arc welding process. Such joint or rail ends to be thermite welded, must have the entire electric arc weld area plus 4 in (102 mm) beyond, removed by saw cutting;

g) All weld gaps must be cut with a rail saw:

i. If the rail must be torch cut, the torch cut must be trimmed with a rail saw. A minimum of 4 in (102 mm) must be removed from all torch cuts.

h) All saw cut rail ends must be dye penetrant tested;

i) Remove ballast for 4 in (102 mm) below the gap;

j) Ensure that there is a clear walkway to the waste disposal area or bin.

k) If this is not a rail puller assisted or closure weld, then tighten anchors for at least 50 ft (15 m) in each direction from gap;

l) It is critical all anchors or fasteners are tight, and the track secured. If the rail moves during the weld process:

i. The gap could change, and the rail ends will not be heated correctly;

ii. The fusal paste around the moulds may crack, causing a run-through.

m) Remove fasteners for 1 or 2 ties to each side of the gap.

n) Reference marks and match marks must be made in accordance with the Metrolinx Track Standards (formerly GTTS).

o) Check that the shear and grinder are operational and fit the rail.

10.5.4 **Rail end preparation:**

a) Ensure that the plug rail must be rail flaw tested (UT) and marked in accordance with the Metrolinx Track Standards (formerly GTTS);

b) Ensure that the weld gap is not positioned over a tie nor closer than 4 in (102 mm) to the edge of a tie;

c) The rail metallurgy must be of equal grade or better than what is in track;

d) Inspect rail ends for batter, bolt holes for cracks, defects and previous weld material (if any of these are noted or present, the joint must not be thermite welded);

e) Verify that any drilled holes are further than 4 in (102 mm) from the rail end and have been deburred. Closely inspect for any signs of cracking or damage. Dye penetrant test the drilled holes if necessary;

f) Rail ends must:

i. Always be cut with a rail saw;

ii. Be square and perpendicular within 1/8 in (3 mm);

iii. Not have been previously welded by gas or electric welding;

iv. Not be welded if rail end batter is present and cannot be cut out;

v. If the gap is saw cut, the removed silver must be dye penetrant tested.

g) Verify rail ends are cut square and perpendicular with a tolerance 1/8 in (3 mm);

h) Clean each rail end with a wire brush for at least 4 to 6 in (100 to 150 mm). Flame clean if necessary to ensure all dirt, oil, grease, paint, or other foreign material is properly cleaned and removed. Lightly grind and clean if needed;

i) The weld area is defined as 18 in (0.5 m) on either side of the gap;

j) Cadweld or pin brazed bonds must be removed by grinding only. They must never be chiselled off. All copper must be ground to ensure it is adequately removed; and

k) Remove all metal flow or lip on both the gauge and field side, at the rail head by grinding to ensure proper fit of moulds and rail weld shear.

10.5.5 **Rail end alignment:**

a) Alignment can be one of the most difficult and critical procedures in any thermite welding process. Inconsistent work will lead to premature weld failure. There are five sub-steps to correctly align the rail ends for a thermite weld;

b) Eyeballing the weld (for both wood and concrete ties):

i. Before beginning the alignment procedure, assess the general level of the roadbed, looking for problems such as:

1) Hanging ties; and

2) Low joints.

ii. If hanging ties or a low joint exists, surface the area before continuing with the alignment procedure;

iii. Remove any splice bars as well as any spikes, anchors, rail fasteners, tie pads or insulators for one or two ties to either side of the weld location;

iv. Next, “eyeball” the alignment of the weld location by bending over the rail and sighting along the upper fillet – the area just underneath the rail head on the gauge side;

v. Look to see if the peak of the rail ends is:

1) Level;

2) High;

3) Low; and

4) Unequal.

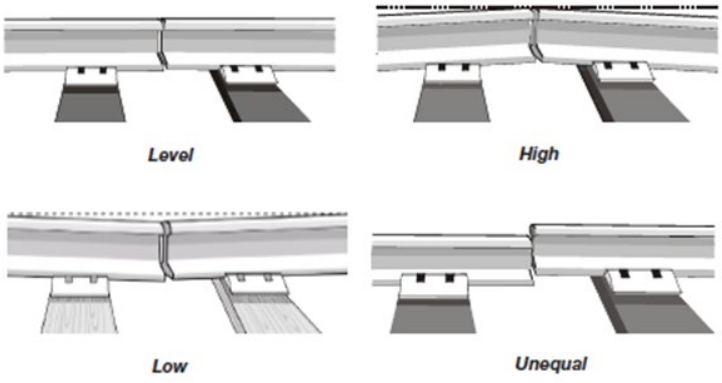


Figure 10-7: Vertical Alignment of the Rail

vi. Finally, determine if the horizontal alignment is:

1) In;
2) Out; and
3) In-line.

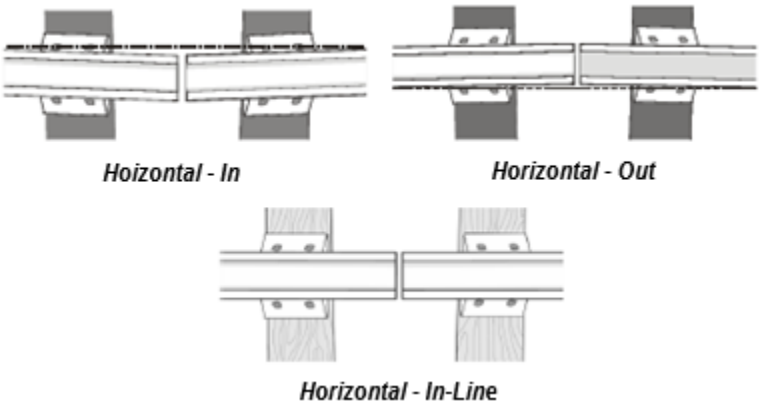


Figure 10-8: Horizontal Alignment of Rail

vii. Eyeballing the rail gives important information on:

1) What rail movement will be necessary to align the rail ends; and
2) Where to position the wedges, spikes, and track jacks to achieve alignment.

c) Gap (for both wood and concrete ties):

i. Measure the gap at both sides of the rail head and base;

ii. The standard gap weld must be:

1) A minimum of 1 in (25 mm) to a maximum of 1 1/8 in (28 mm) for standard 1 in (25 mm) gap welds;

Note: Extra preheat for 30 seconds may be required at 1 1/8 in (28 mm).

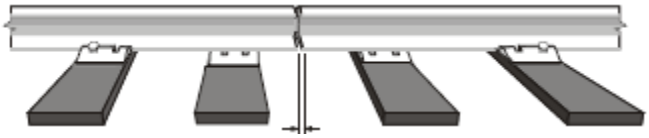


Figure 10-9: Allowable Gap for Thermite Welding

iii. If using a rail puller to achieve proper gap, follow all manufacturer's rail puller safety procedures:

1) Remove anchors or clips for a minimum of 75 ft (23 m) on both sides of the weld. Additional rail restraints may have to be removed to achieve the proper weld gap; and

2) A rail puller is required on all closure welds when the rail temperature is at or below the Preferred rail laying temperature (PRLT).

iv. Never add or remove steel to the rail length unless otherwise directed, as it will affect the stress-free temperature of the rail;

d) Peak (vertical alignment) for wood ties:

i. For safety reasons, alignment plates/jacks are the preferred method for lining rail, and are required whenever using the rail puller;

ii. Steel wedges are allowed for use, when not using the rail puller. They:

1) Must be made of AREMA grade "B" steel;

2) Must have a protective cover or boot over the striking surface; and

3) Can be used outside of the rail puller Red Zone to assist with twist or cant.

Figure 10-10: Rail Wedge
Courtesy Industry Railway Suppliers

iii. Tap in one wedge on the gauge and field sides, on both sides of the gap, just enough so that each tie plate is snug up against the rail base:

1) Adze any plate-cut ties to help position the wedge or alignment plate.

iv. Place a Welder's straight edge across the gap, centring it on the running surface. The clearance between the end of the straight edge and the running surface is how you measure the "peak";

v. Taking into consideration what was seen when the rail ends were "eyeballed" and what the straight edge indicates, adjust the crown until the correct peak at both ends of the straight edge is achieved;

vi. If a rail end is too high (without wedges), lower it by jacking up the high rail with a track jack placed 8 to 12 ties back from the rail end. If using track jacks to assist with alignment, they must remain in place until the weld has cooled below 700 °F (371 °C);

Example: When levelling track, while welding switches out of track.

vii. Check the "peak" or "crown" using a Starrett taper gauge. For 5 ½ in (139 mm) rail base or smaller, set the crown between 0.065 to 0.070 in (1.6 to 1.7 mm), and for 6 in (152 mm) rail base, set the crown between 0.070 to 0.075 in (1.7 to 1.9 mm):

1) Proper crown is best achieved using a magnetic adjustable straight edge, calibrated with a taper gauge, at a minimum of once daily prior to initial weld.

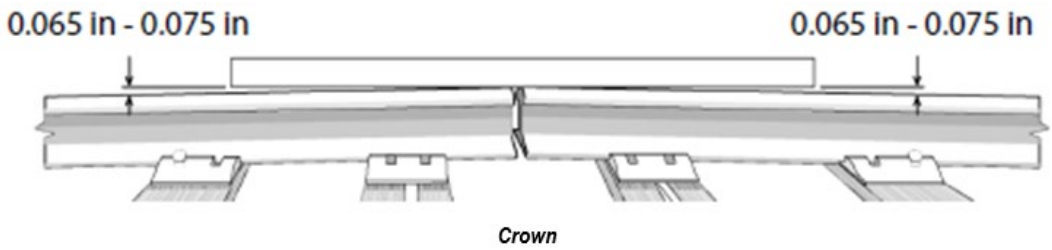


Figure 10-11: Allowable Crown

viii. Do not "hump" the track. Raise the rail spikes by 1 in (25 mm) or remove elastic fasteners;

ix. Never step on the rail during alignment;

x. Don't step on the ties that are supporting the weld crown or alignment until 5 minutes after the pour; and

xi. Rail movement and vibration must be avoided from the finish alignment process until 5 minutes after the pour is completed. Caution must be taken when welding in close proximity to a road crossing with traffic and to adjacent tracks, which might induce excessive vibration.

e) Peak (vertical alignment) for concrete ties:

i. The alignment process for rail ends on concrete ties is different because there are no tie plates to wedge, and spikes cannot be used to adjust the horizontal alignment;

ii. For safety reasons, alignment plates/jacks are the preferred method for lining rail, and are required whenever using the rail puller.

iii. Ensure that the tie pads have been removed;

iv. Place a Welder's straight edge centred on the running surface of the rail across the gap;

v. For concrete ties, check the "peak" or "crown" with a straight edge and Starrett taper gauge. For 5½ in (139 mm) rail base or smaller, the crown must be between 0.065 to 0.070 in (1.6 to 1.7 mm) and for 6 in (152 mm) rail base, the crown must be between 0.070 to 0.075 in (1.7 to 1.9 mm);

vi. Taking into consideration what was seen when the rail ends were eyeballed and what the straight edge indicates, position one wedge under the rail on the side that appears to be furthest out of line;

vii. Do this on the first tie on both sides of the weld location;

viii. Adjust the wedges until you have the correct peak at both ends of the straight edge (alignment plates or A-frames are available to use for concrete ties);

Figure 10-12: Rail Alignment tools

Courtesy Industry Railway Suppliers, Pandrol and JB Railroad

ix. If a rail end is too high (without wedges), lower it by jacking up the high rail with a track jack placed a minimum of 8 to 12 ties back from the rail end;

x. Be careful not to "hump" the track. Remove fasteners if necessary; and

xi. If using track jacks outside of weld gap area to assist alignment, they must remain in place until the weld has cooled down below 700 °F (371 °C).

f) Horizontal alignment for wood ties:

i. Check both sides of the head, web and base for the entire length of the straight edge across both rail ends;

ii. If the head, web or base of one rail is wider than the other, divide any difference in width equally, keeping the straight edge parallel to the surface;

Figure 10-13: Checking the Head and Base with a Straight Edge

iii. Taking into consideration what was seen when the rail ends were eyeballed and what the straight edge indicates, determine which rail is out of line and to which side–gauge or field;

iv. Move the out-of-line rail back into alignment using the tie plate. This is done by driving a spike straight down, at least halfway into the tie, against the outside of either the gauge or field side of the tie plate under the out-of-line rail;

v. Alternatively, a spike can be driven about 3/4 in (19 mm) away from the end of the tie plate, and a rail positioner wedge driven on its side between the spike and the tie plate to move the tie plate;

vi. Do not hit the rail with the hammer. Move the rail with the tie plate;

vii. Do not drive the spike in at an angle. It will cause the tie plate to ride up on the spike;

viii. Check the horizontal alignment with a straight edge placed against the gauge side of the base of both rails and across the gap;

ix. Repeat this procedure until the base of the out-of-line rail is back in line; and

x. In a curve, using a rail positioner wedge or alignment plates will make the job easier.

g) Horizontal alignment for concrete ties:

i. If either of the rails is out-of-line, remove the gauge or field side rail fastener from the second tie from the rail end, and position a short wedge on its side between the rail base and the casting shoulder.

ii. Check the horizontal alignment with a straight edge against the gauge side of the base of the rail across the gap;

iii. Tap the sideways wedge in or out to adjust the base of the out-of-line rail. Do not hit the rail;

iv. If available, a "rail alignment beam" will facilitate peak and horizontal alignment on concrete ties, especially in curves or at level crossings; and

v. A "rail positioner" can also be used in curves to maintain horizontal alignment.

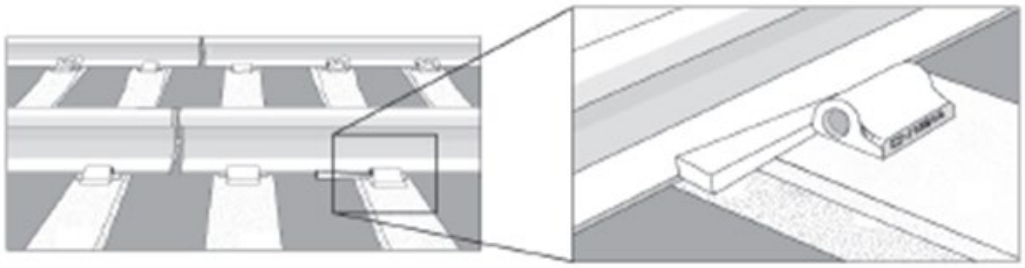


Figure 10-14: Using a Rail Positioner

h) Unequal cant between rail ends on wood ties:

i. Check the gauge side of the heads and bases across the gap with a straight edge;

ii. If the bases are aligned but the heads are not, unequal cant between the rail ends is present;

iii. The rail with the head tipped the furthest out is the rail with excessive cant;

iv. Raise the spikes on that rail for a minimum of 12-15 ties back from the rail end on the side with excessive cant;

v. On the same side of the rail, place a wedge under a tie plate 12-15 ties back to "roll" the rail back into alignment;

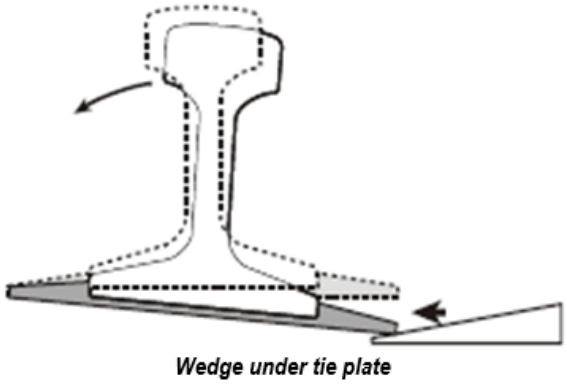


Figure 10-15: Correcting rail cant

vi. Hold a straight edge on the gauge side of the heads and tap the wedge until the heads align;

vii. Recheck the gap, peak, horizontal alignment and unequal rail cant between rail ends and adjust accordingly;

viii. In a curve, using gauge rods will make the job easier;

ix. If available, a rail canter, instead of a wedge, placed 4 ties back from the rail end can be used to correct unequal cant between rail ends; and

x. Never try to adjust unequal cant between rail ends at the immediate weld location.

i) Unequal cant between rail ends on concrete ties:

i. Check the gauge side of the heads and bases across the gap with a straight edge;

ii. If the bases are aligned but the heads are not, unequal cant between rail ends is present;

iii. The rail with the head furthest out is the rail with excessive cant;

iv. On the side with excessive cant, remove the rail clips one at a time, working away from the rail end;

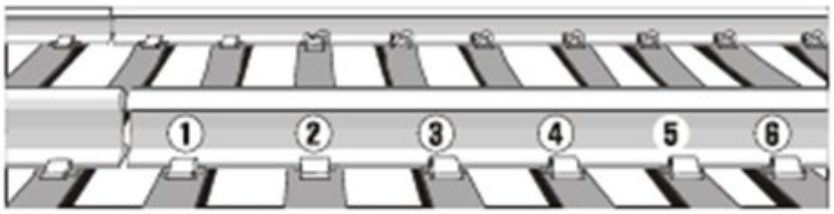


Figure 10-16: Sequence of Removing Rail Clips

v. If the heads are not aligned after removing six rail clips, tap in a wedge under the rail base 12-15 ties back on the same side of the rail to "roll" the rail back into alignment;

vi. Recheck the gap, peak, horizontal alignment and unequal cant between rail ends and adjust;

vii. If available, a rail canter placed four ties back from the rail end can be used instead of a wedge;

viii. An incorrect gap can result in a poor bond between the rail ends;

ix. Incorrect peak means the running surface will be too high or too low when the weld cools. This causes wheel impacts;

x. Poor line will result in an irregular gauge;

xi. When possible, roll rail in to maintain gauge.

xii. Unequal cant between rail ends will promote fatigue weld failure through twisting or rotation; and

xiii. Removing alignment assist jacks too early will result in a misaligned weld.

10.5.6 **Mould preparation:**

a) Prepare and assemble the mould components and apply fusal paste. This is another critical area where poor workmanship will lead to weld defects.

b) Protect mould from moisture;

c) Verify weld kit contents are the correct size for the rail being welded, including offset base brick if needed for vertical offset 1/8 in (3 mm) or greater;

d) Inspect moulds to ensure:

   i. That they are not cracked, damaged, or warped;

   ii. There are no signs of moisture;

   iii. The riser holes are open and free of debris; and

   iv. The moulds have not exceeded their 2-year shelf life.

e) Mark all four corners of the outside base of rail 2½ in (64 mm) from the weld gap, with a paint marker or preferred 450 °F (232 °C) temperature indicating stick (Tempilstik);

f) Rub side moulds on rail for a tight fit;

g) After rubbing moulds, remove all mould sand from rail ends and weld area of moulds;

h) Pandrol Hybrid moulds must not be rubbed into rail for fit. Care must be taken not to remove or tear packing felt strips from moulds while installing;

i) Make sure side moulds don't extend below the bottom of the base when dry fitting to the rail;

j) Dry fit the base brick to the rail prior to applying paste. Check for twist in rail ends or a warped base brick. Place base brick in base plate;

k) Squeeze clay cement in grooves on the base brick no more than the thickness of a pencil. Too much could smear into the weld fillet, causing a defective weld;

l) Place the mould plate retaining screws;

m) Centre base plate and brick with equal gaps on all four corners. Make sure rail plate hooks are not bent, causing the base brick fillet to be offset to one side:

   i. To centre the base plate under the gap, make sure that the distances between the end of the rail and the recess in the bottom brick are the same.

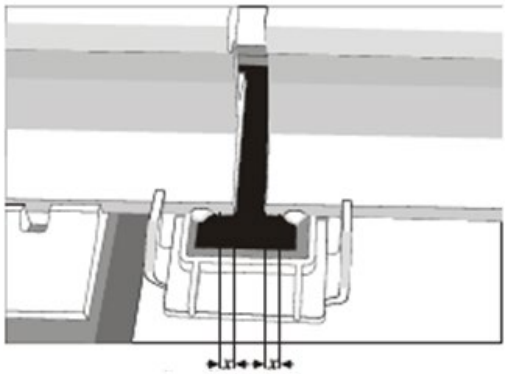


Figure 10-17: Centring the Base Brick

n) Tighten retaining screws until snug, but do not overtighten;

o) Recheck alignment with a straight edge:

   i. Check the alignment after the base plate is clamped on. This is the last chance before installing the side moulds.

p) Place side moulds in jacket. Make sure that the mould shoes and jackets are not bent or warped and securely fit the moulds;

q) Place side mould with overflow spout on the low side of rail;

r) Ensure side moulds are even on the base plate and centred on gap;

s) Clamp mould jackets, but do not overtighten and risk cracking the moulds;

t) Recheck all corners and side of mould to ensure moulds have not moved or twisted away from the rail while tightening the mould clamp in place:

   i. Cover the top of the mould opening with a piece of cardboard to prevent anything from falling in.

u) Smear a thin layer of packing mud around the entire mould rail matting surface;

v) Back up the thin layer with a larger bead of packing mud:

   i. Too much will not dry properly and will cause moisture defects; and

   ii. Too little will dry and crumble, promoting a run-through.

w) Place packing mud on the overfill drain spout and over the clamp threads to protect the hardware from leaking molten steel;

x) Line slag basin with dry sand or crushed material from crucible cap;

y) Place a box of dry sand or pan to protect the area under the moulds, if there is a presence of moisture or frozen ballast conditions; and

z) Rail movement and vibration must be avoided from the finish alignment process until 5 minutes after the pour is completed.

10.5.7 **Preheating:**

a) Preheating is an operation of primary importance to the successful completion of the thermite weld. Its function lies in the elimination of residual moisture from the moulds to increase the temperature of both rails and the moulds.

b) All preheating equipment must be in proper working order to complete the preheating process. The preferred method of preheating thermite welds is the air–propane process. The oxygen–propane process is also acceptable.

c) Since conditions may vary between trucks and equipment, or if the tank's fill level is low or the contents are cold, increase the fuel pressure to achieve the proper preheat rail temperature of 450 °F (232 °C) on all four corners of the base.

d) Note and record the rail temperature on the Thermite Welding Form;

e) Preheating equipment must be aligned for each weld to ensure that it is centred along the rail and in the welding gap of the moulds:

   i. Position and adjust the burner and its support stand, ensuring:

   ii. It is in line with the vertical axis of the rail (not pointing to the field or the gauge side);

   iii. It is vertically straight (at a right angle to the base of the rail); and

   iv. The burner tip is perpendicular to the ground (not angled up or down).

f) Setting the burner height above rail head:

   i. Set the air blower torch height even with the top gate collar.

Figure 10-18: Air Blower Torch Height Set into Moulds

g) The oxygen–propane torch heights differ for each manufacturer of welds:

   i. Pandrol: 1 in (25 mm) gap welds: 1 ½ in (37 mm);

   ii. Orgo-Thermit: 1 in (25 mm) gap welds: 1 3/8 in (35 mm).

Torch Alignment:

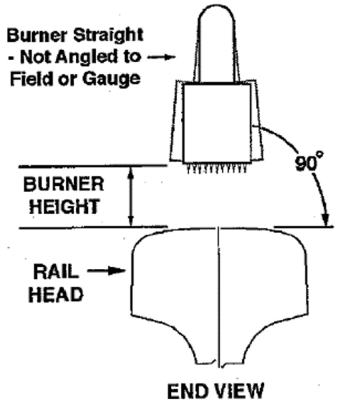


Figure 10-19: Proper Burner Alignment

iii. The burner height must be checked at a minimum of once per day prior to preheating the first weld; and

iv. The burner must be straight and not lined to the gauge or field side.

h) Angle the nozzle to the side to facilitate lighting;

i) Start the preheating process:

i. The preheating process must begin within 10 minutes of packing the weld moulds. Longer than this may result in the packing clay or sand drying out and falling off during the heating process, causing a runout or leak.

j) Ignite the torch nozzle and reposition it:

i. The torch must be lit with a friction striker *only;*

ii. If using the oxygen-propane preheating process, pressures must be maintained at 65 psi for oxygen and 15 psi for propane with in-line gauges at the torch;

Figure 10-20: Position of In-line Gauges and Flashback Arrestors

iii. Ensure the flame is burning evenly and that there are no clogged orifices (if dirty, the torch must be shut off and cleaned);

iv. Ensure the air blower is adjusted in the moulds to create the sound of a turbojet engine;

v. If using the oxygen-propane process, adjust the burner so that there is approximately a 7/8 in (22 mm) feathered flame;

Figure 10-21: Oxygen-Propane Proper Feathered Flame Length

vi. Make sure the flame is burning in the mould, not just above the mould gates;

vii. At the same time, verify that the flame is directed straight and downwards into the mould; and

viii. Ensure the air blower torch collar is even on the four groove tops inside the mould.

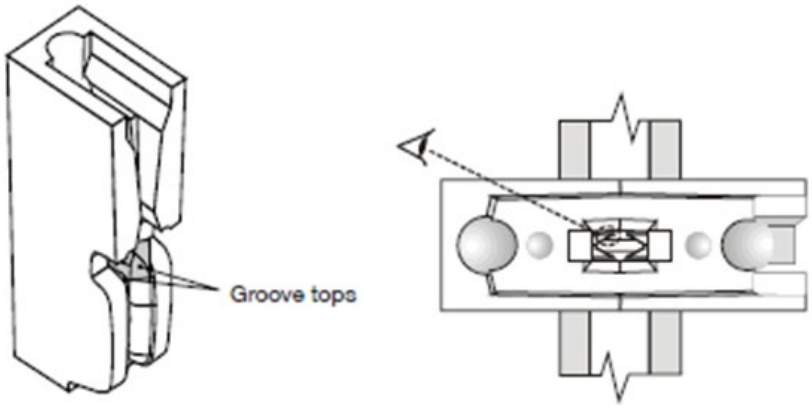


Figure 10-22: Setting the Air Blower Torch Collar

k) Adjust the flame height:

i. Using air blower process, the flame height will be approximately 6 to 8 in (152 to 203 mm) above the mould riser hole; and

ii. Using the oxygen-propane process, the flame height will be approximately 30 to 36 in (762 to 914 mm) above the mould riser hole.

l) The preheating time will differ according to rail size and amount of rail wear:

i. The preheating time starts after adjustment of the flame and fine-tuning the torch alignment. A stopwatch is the easiest and most accurate way of performing this task. The time is only a reference, and proper rail end colour (orange) and achieving a temperature of 450 °F (232 °C) on all four corners of the base is required; and

ii. A minimum of 5 minutes of preheating is required, but not to exceed 8 minutes, as mould damage could occur.

m) Place the diverter plug on the edge of the mould to preheat the plug;

n) It is the Welder's responsibility to monitor the entire preheating process:

i. Once the preheating starts, constantly monitor the preheating process to ensure all the rail ends are not melted and there is no breakdown of the moulds. (If the rail is melted, then the entire process must be started over.);

ii. For eye protection, a minimum number 5 lens or face shield must be worn when monitoring the preheating process;

iii. Achieving uniform and proper colour of the rail ends (centre of the rail web & base: yellow/orange). The true colour of the rail ends can only be observed with the torch removed;

iv. All minimum times must be achieved. Additional time may be required depending on weather conditions and rail size. Use a 450 °F (232 °C) temp stick, 2 ½ in (64 mm) from the rail ends, to test the rail for proper preheating. Laser temperature guns are not allowed for this reading as the radiant heat reflection from the preheating will give false indications; and

v. Do not turn down the propane pressure on the torch prior to removing it from the moulds (this will cause the oxygen–propane heating torch to turn into a cutting torch and will melt the rail ends).

o) After the preheat is completed and the torch has been removed, check the moulds to ensure that they have not been damaged and no foreign objects have fallen into the moulds;

p) Ensure the slag pans (dry and filled with sand) are placed on the mould; and

q) Gently place the diverter plug, ensuring a snug fit (do not tap it).

10.5.8 **Charge preparation:**

This is completed in conjunction with the preheating process:

a) Set up the crucible in a dry and level location close to the work area;

b) Check the charge bag for:

i. Signs of punctures or moisture;

ii. Shelf life not exceeding 5 years.

c) Inspect the crucible for any damage or debris, removing any loose sand;

d) Verify the tapping thimble is in place and securely seated and not loose;

e) Remove the charge I.D. tag and attach it to the Thermite Welding Form (the batch number and date are required for reporting);

f) Reinspect the charge bag for any signs of damage (rusty or loss of material) prior to pouring the contents into the crucible;

g) Stir the charge by hand and make a mound in the centre (if using the Startwel ignition system, the charge must be flat, not mounded);

h) Insert an ignition fuse and cover the crucible.

i. Place the packing boxes and charge bag in the disposal hole. Do not burn or destroy packing boxes until the weld is completed. If something goes wrong, the packing information on the mould or crucible boxes will be needed. Make sure to record the charge bag batch number and the date. Place all packaging material on the back of a truck and remove it from Metrolinx property for environmental disposal. Such material is never to be left on or buried along the Right of Way. Never discard packaging in the same container as hot waste material.

i) Before opening, always verify:

i. The crucible has not exceeded a shelf life of 2 years;

ii. The crucible is clean, free of defects with no cracks;

iii. The thimble is securely in place; and

iv. The charge bag is sealed and dry.

10.5.9 **Pouring:**

a) Wear Welder's goggles or a face shield (minimum No. 5 shade lens) and Welder's gloves;

b) When the temperature reaches 450 °F (232 °C) on all four corners of the base, remove the burner nozzle from the mould;

c) Carefully place the charged crucible centred on the moulds so that equal amounts of both riser holes are visible;

d) Ignition must be performed immediately after preheating and within 15 seconds after the removal of the torch;

e) Light the ignition fuse on the hot mould by lightly touching it to the mould riser hole, do not rub. Do not chip or knock any mould sand particles into moulds;

f) Insert the ignition fuse into charge a maximum of 1 in (25 mm);

g) Replace the crucible cover;

h) Tap time begins when the charge ignites and stops when the pour begins. Normal tap time is between 15 to 35 seconds. For any times outside of this range, the weld must be considered defective. The weld must be protected and must be replaced as soon as possible;

i) After igniting the charge, ensure everyone has moved to a safe distance and clear of the weld area by a minimum of 40 ft (12.2 m). View the tap and pour, remaining in the clear for at least 1-minute and until the reaction and pour are complete:

   i. In the event of a runout or leak, no attempt is to be made to stop the leak (pogo mud sticks are not allowed).

j) When the slag stops pouring, start the stopwatch for tear-down time. (Last drip in the slag pan;) and

k) Rail movement and vibration must be avoided from the finish alignment process through the weld solidification process:

   i. Don't hit, step on or move the rail being welded;

   ii. The weld solidification occurs when 5 minutes have passed after the end of the pour; and

   iii. Note any out-of-the-ordinary movement on the weld report (working next to a road crossing, trains going by on adjacent tracks, etc.).

10.5.10 **Demoulding and Shearing:**

a) Using a stopwatch, ensure that nothing is started until 5 minutes after the pour is complete.

b) Ensure the shear is ready and properly adjusted to the rail size being welded;

c) Remove the slag basin and crucible:

   i. The slag pan must be removed and set in a secure dry area and not emptied until 15 minutes after the pour.

d) Remove the mould clamp and mould jackets;

e) Score the top of the mould with a hot cut;

f) Using a demoulding tool or a sledgehammer, push the top of the mould into a shovel and place in a dry waste disposal area bin, box or barrel;

g) Push riser down just enough to allow profile grinding (approximately 45° to 60° angle). Avoid knocking them off. The rise helps control the cooling process and must not be removed until the weld has cooled below 900 °F (483 °C). The outside risers may fall if bent too far;

h) Remove any dry fusel paste from the running surface;

i) Don't strike the rail with a hot cut or other tools in an attempt to remove mould material;

j) Start the shearing 6 ½ minutes after the pour (+/- 30 seconds);

k) Shear the excess weld material and place it in a dry waste disposal area, bin, box or barrel;

l) Carry the slag basin level so that hot weld material will not spill out;

m) Never dispose of hot weld material in water, snow or on frozen ballast;

n) Do not place a hot slag basin on a concrete tie; and

o) Do not empty the contents of the slag basin until it has cooled for at least 15 minutes.

10.5.11 **Hot grinding:**

a) Wear all required personal protective equipment:

i. Face shield, goggles;

ii. Hearing protection;

iii. Respirator (recommended); and

iv. Leggings.

b) Ensure you have firefighting equipment available and ready for use;

c) Check grinding stones and equipment prior to use;

d) Grind weld metal to 1/32 in (0.8 mm) above carbon steel rail. This is not the final finish grind. It is getting close while allowing all other finishing work to be completed on time and within the temperature limits;

e) Grind contour radius flush or blend-in; and

f) Grind gauge and field side flush or blend-in;

10.5.12 **Rough grinding:**

a) Rough grinding of the rail head portion of the thermite weld may be performed after the head riser is removed and the weld has been sheared;

b) Rough grinding is completed when the excess weld metal is reduced to approximately 0.030 in (0.76 mm) above the rail surface. Grinding only the weld area and not the parent carbon steel rail (stay on the weld);

c) After the rail head has been rough ground, the gauge and field faces may be rough ground to within 0.015 in (0.38 mm) above the rail surface;

d) Crown wedges or alignment plates/jacks must be removed 20 minutes after the pour to allow the weld to return and reduce to normal vertical alignment;

e) The base plate and risers must be removed when the weld reaches a temperature of 900 °F (483 °C) (approximately 22-25 minutes after the pour);

f) All base risers must be ground flush with the weld collar. This will ensure weld quality and that any sharp edges are removed to prevent premature weld failure**;**

g) ***Note:*** The only exception to this is in areas between the switch point and stock rails and the toe and heel of frogs where a hand grinder will not fit.

h) During cold weather temperatures below 40 °F (5 °C), the weld must be covered with a cooling blanket or box until the weld has cooled to below 900 °F (483 °C).

10.5.13 **Hot finish grind (above 600 °F):**

a) It must be understood that the vertical crown will continue to reduce until the weld has cooled to ambient temperature. Over-grinding when hot will result in a low weld:

b) Finish grinding of the weld must be performed after the above has been completed and the weld area has cooled to below 900 °F (483 °C) but above 600 °F (316 °C);

c) Finish grind the weld to leave the weld 0.005 to 0.007 in (0.13 to 0.18 mm) high, measuring at the weld heat lines on each side of the weld, and not at the end of the straight edge;

d) Grind the weld only; don't dig holes in the parent carbon steel rail. (Stay on the weld.);

e) Grind the required tapers of the head, gauge, and field faces if any vertical or horizontal offsets are present;

f) Grind radii on both the gauge and field corners to match existing rail contours;

g) When rough grinding, it is essential to leave at least 1/32 in (0.8 mm) of the weld metal on the running surface above the carbon steel rail;

h) **Reminder:** This is not the final finish grind; it is getting the weld close to allow all other work to be completed at temperature and time limits.

i) Grinding the weld metal flush with the carbon steel rail when the weld is still hot, above 900 °F (483 °C), results in a low weld after it cools;

j) Remove the crown alignment wedges or plates at 900 °F (483 °C) (approximately 20-25 minutes after the pour) to allow the weld to cool to level;

k) If track jacks were used outside of the weld gap area to lower rail ends, remove them after the weld has cooled below 700 °F (371 °C). This is approximately 35 minutes after the pour, depending on weather conditions, rail size and wear.

Example: when welding switch panels out of track. This is not the rail crown alignment jacks;

l) The rail puller can be removed at any time after the weld has cooled below 700 °F (371 °C). This is approximately 35 minutes after the pour:

i. Make sure all rail fasteners are replaced and tight.

10.5.14 **Cold Grinding:**

a) If the weld cannot be finished ground above 600 °F (316 °C), no finish grinding is allowed until the weld has cooled below 400 °F (204 °C). This is typically 50-60 minutes after the pour:

b) Finish grind the weld to leave the weld a maximum of 0.015 in (0.38 mm) high to 0.000 in (0.00 mm) low. Measure with a taper gauge at each end of a 36 in (914 mm) straight edge, centred at 18 in (457 mm) on the weld;

c) Grind the weld only. Do not dig holes in the parent carbon steel rail;

d) If necessary, grind the required tapers of the head, gauge, and field faces if vertical or horizontal offset is present:

i. Gauge and field taper lengths:

Table 10-3: Weld Offsets and Taper Length

OFFSET			GRINDING TAPER LENGTH (T) INCHES			
X (inches)	Fractional Equivalent For Maximum	MM Equivalent For Maximum	VERTICAL OFFSET	HORIZONTAL OFFSET		
				GAUGE		FIELD
				FACE	CURVE WEAR, FLOW LIP	WEAR, FLOW LIP
0.01			6	6	6	6
0.011 - 0.020		0.50 mm	12	12	12	6
0.021 - 0.030	1/32	0.76 mm	18	18	18	6
0.031 - 0.040		1.01 mm	24	24	24	6
0.041 - 0.050		1.27 mm	30	30	30	6
0.051 - 0.060	1/16	1.52 mm	36	36	36	6
0.061 - 0.080		2.03 mm	48	42	36	6
0.061 - 0.125	1/8	3.17 mm			42	6
0.126 - 0.188	3/16	4.77 mm			42	
0.189 - 0.250	1/4	6.35 mm			48	
0.251 - 0.313	5/16	7.95 mm			48	
0.314 - 0.375	3/8	9.52 mm			72	
0.376 - 0.500	1/2	12.7 mm			72	

e) Grind radii on both the gauge and field corners to match existing rail contours.

f) Ensure the base risers have been removed and ground flush with the weld collar.

g) Cold grind the weld metal flush to the rail surface and blend in where necessary:

i. Grinding tolerances must be measured at a temperature at or below 200 °F (93 °C).

Table 10-4: Weld Grinding Tolerances

Measurement	Dimension	Tolerances for Thermite Welds
Crown: Peak of the rail at the weld	A	0.030 in (0.76 mm)
Vertical Offset: Vertical difference on the rail head	C	0
Dip Camber	E	0
Horizontal Offset: Horizontal difference on side of the rail head	B	0.015 in (0.38 mm)
Indent - Kink to field side	D	0.030 in (0.76 mm)
Intent – Crown inward (peak) toward track centre	D	0.030 in (0.76 mm)

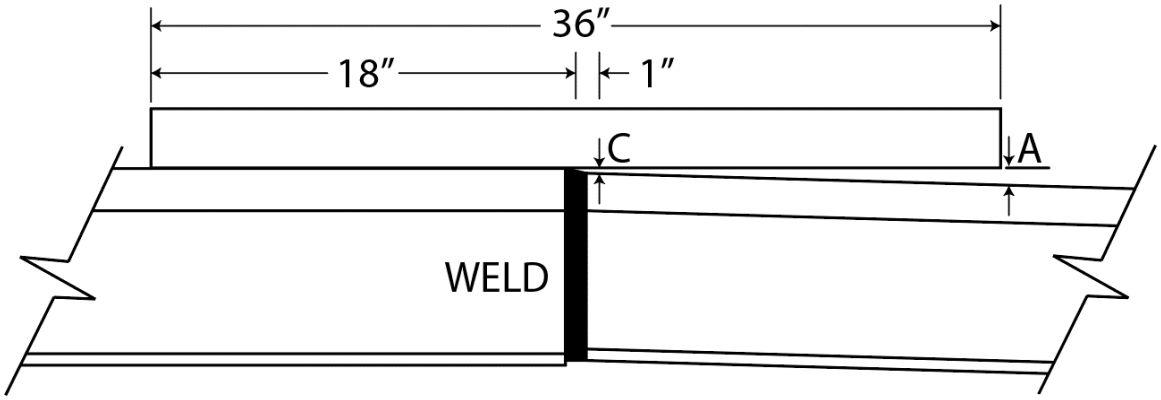


Figure 10-23: Vertical Weld Grind Offsets

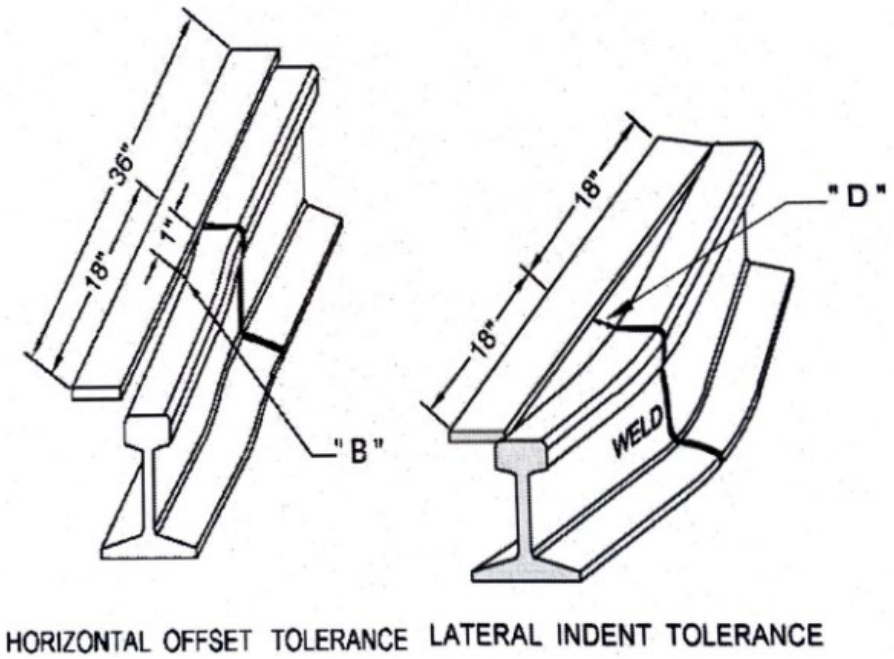


Figure 10-24: Horizontal Weld Grind Offsets

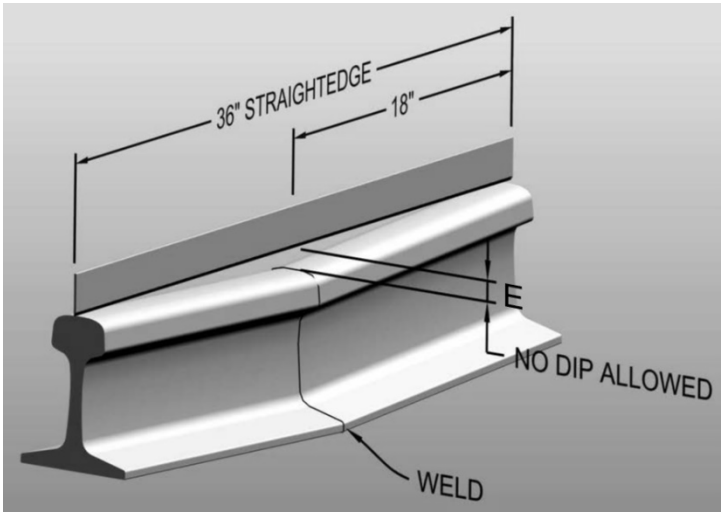


Figure 10-25: Dip Camber Tolerance

10.5.15 **Finishing:**

a) Visually inspect the weld. Use the straight edge, ensuring the weld complies with the Metrolinx Track Standards;

b) Tamp a minimum of 2 ties to each side of the weld plus any others that need to be tamped. Fill in and dress all ballast around weld crib and tamped ties;

c) Plug or glue all wood ties and replace all rail fasteners and/or insulators;

d) All anchors have been replaced to match the existing pattern:

   i. 200 ft (61 m) in each direction from the weld.

   ii. ***Note:*** No anchors will be applied within 2 in (51 mm) of the weld.

e) Clean up the area, pick up all weld waste material, and properly dispose of it. Thermite welding debris must be removed from Metrolinx property on the same shift or within 24 hours of completing the thermite weld and must not be buried on any portion of Metrolinx Right of Way;

f) Load tools, thermometer, etc. This includes picking up all OTM bars and rail. If there is no means to load rail, it must be rolled out of the normal walking area of trainmen;

g) Each weld must be labelled in permanent white paint marker on the gauge side of the rail (within 3 ft (914 mm) of the weld) with the following:

   i. Identification of welder (Thermite welder's initials);

   ii. Date of weld (DD-MM-YY);

   iii. Consecutive weld number;

   iv. Length of rail added or removed;

   v. Rail temperature at the time of welding;

   vi. Method of controlling rail: hydraulic rail expander (E) or rail heater (H); and

   vii. Dye Penetrant test completed on both rail ends and indicated with the letters DP;

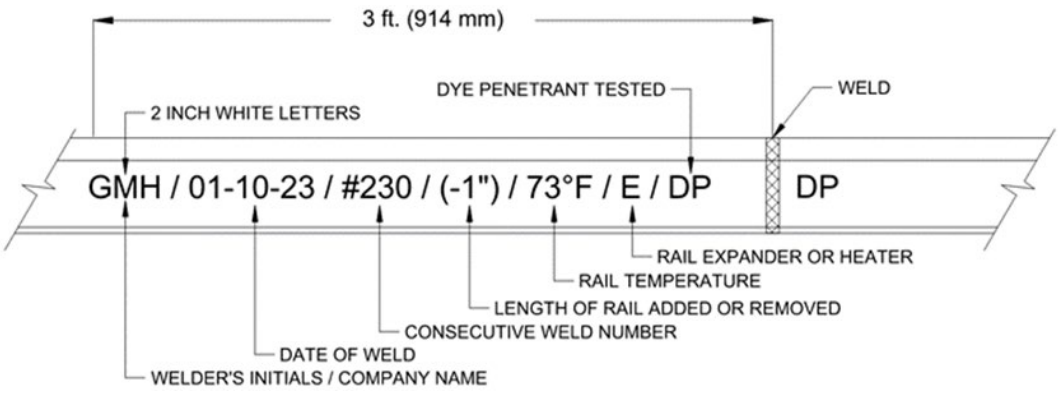


Figure 10-26: Weld Information Marking

h) All required weld information must be recorded on the Metrolinx Thermite Welding Form;

i) Inspect the entire work area for any signs of smoke or smouldering material. If necessary, leave Fire Watch with an adequate water supply;

j) Clear all equipment and personnel from the site; and

k) Cancel track protection when safely in the clear.

10.5.16 **Testing:**

a) All thermite welds must be tested ultrasonically in accordance with the most common industry test practice for the ultrasonic inspection of rails.

   i. Ultrasonic testing must be completed within 72 hours upon completion of thermite welds; and

   ii. Test reports (with results indicating pass or fail) must be submitted to Metrolinx E&AM - Track within 48 hours of testing.

10.6 Emergency Procedures and Precautions for Thermite Welding

10.6.1 Freeze-up of crucible: one rare and potentially dangerous situation that may be encountered is a freeze-up of crucible. This is a condition where the charge ignites, but the weld doesn't pour out within one minute. Normal tap time is between 15-35 seconds from the time of the ignition of the charge material until the crucible pours at 90 seconds. This is in line with the riser hole and will pour into moulds. Never attempt to remove the crucible once the charge has turned to molten steel. This crucible is extremely brittle and could crumble if an attempt is made to move it, pouring liquid molten steel everywhere. This is an extremely dangerous situation which could cause severe injury or death.

10.6.2 If a freeze-up of the crucible happens:

a) Leave the crucible where it is and clear the weld site;

b) Return after the crucible has been discharged and cleaned up;

c) Advise the RTC and Supervisor of the problem immediately; and

d) Cut out the weld and cut in a closure rail.

10.6.3 If the crucible does not tap out the primary tap hole or the bypass tap hole:

a) Do not move or touch it until it has been allowed to cool for a minimum of 30 minutes;

b) Remove it from the moulds, carefully setting it in the clear; and

c) Do not attempt to break it up, as there may be liquid steel that is not completely solidified.

10.6.4 During the welding operation, the following precautions must be observed for handling thermite welding materials:

a) Molten steel and molten slag in contact with water, frost, snow or any other form of moisture is very dangerous;

b) To extinguish a metal fire, use only dry sand. The use of vapour-forming extinguishing materials is forbidden;

c) Check the plastic bag containing the charge, ensuring that the bag is sealed and has not been punctured in handling. Any dampness in the charge will cause heavy turbulence and metal spray during the reaction.

d) In the event of a runout or leak, never attempt to stop the leak (pogo mud sticks are not allowed); and

e) Remain in the 40 ft (12.2 m) safe zone for one minute.

10.6.5 Apply weather restriction procedures when required.

10.6.6 Welds must be allowed to cool normally without induced cooling.

10.7 Thermite Welding Kits

10.7.1 All thermite weld kits must meet the rail type (chemistry), weight and section being welded.

10.7.2 Both Pandrol and Orgo-Thermit standard one-inch gap weld kits are approved for thermite welding as follows:

a) With or without allowances for vertical offset; and

b) Maximum vertical base offset of 5 mm for Class 3 Track and above;

11 In-Track Electric Flash Butt Welding

11.1 Overview

11.1.1 The type of weld produced by Electric Flash Butt (EFB) welding is similar to that used to fabricate CWR in the plant. As EFB welding does not introduce additional material to the joint, it is generally considered more structurally sound than a thermite weld. An EFB weld will often last for the life of the rail.

11.1.2 EFB welding employs a high-voltage electric current that melts and fuses the ends of the rail together. It does not add material to the joint, as does thermite welding, which uses a mixture of aluminum powder and iron oxide that gives off great heat when ignited. In addition to producing a much stronger weld, EFB welding is also much faster than thermite welding, taking about seven minutes, whereas thermite welding takes about an hour. The time required for the process will often be doubled when rail pullers are required.

11.1.3 EFB welding involves butting the prepared ends of the rail together, attaching electrodes to both pieces of rail, and then applying a high-voltage current that melts and fuses the rail ends. As the weld proceeds the EFB machine pulls the rails together, thus extruding a certain amount of rail material from around the joint. This material is then sheared and ground off. The joint is then electromagnetically tested for soundness.

11.1.4 **Low consumption EFB welding is not permitted on Metrolinx property.**

11.1.5 Precautions must be taken to prevent electrical shorting of the track circuits. Track shunts may need to be placed or the track circuit completely disconnected prior to EFB welding. Check with the manufacturer's recommendations, along with the S&C Maintainer.

11.2 EFB Welding on Bridges

11.2.1 Welders working on bridges, scaffolds, platforms, and other such work areas higher than the surrounding ground must comply with all Metrolinx and all applicable governmental regulations in the use of lifelines, safety belts, or other safeguards as protection against falling.

11.2.2 Rails which require flash butt welding on bridges must be welded off the bridge and then laid in place on the bridge after all work on the weld is finished:

a) Flash butt welding is not permitted on or within 50 ft (15 m) of any open deck or wooden bridge;

b) Complete a Right-of-Way and Bridge Fire Risk Assessment and Emergency Response;

c) Conduct a thorough job briefing with all personnel involved to determine what will be done in case of an accident or fire that may occur;

d) Where sufficient personnel and equipment are not available to take care of any accident or fire that may occur, welding must not be undertaken;

e) Designated Fire Watch person(s) must be assigned. Such person(s) must understand their duties and ensure that suitable firefighting equipment is in position before the work commences. Where the Fire Watch person(s) is positioned under the bridge, firefighting equipment must also be available on the bridge deck;

f) The wood ties, wooden back walls and bridge timbers, plus the area around the structure, must be wetted with water with a fire retarding foam additive to lessen the chance of fire from hot work activities;

g) When welding is complete, a Fire Watch person(s) must remain at the site until the weld has cooled to ambient temperature.

11.3 Cold Weather Restrictions for EFB Welding

11.3.1 EFB welding is permitted in moderate moisture conditions, such as rain, sleet, or blowing snow, if the following conditions are met:

a) The rail can be kept dry, and no weld head clamp slippage occurs; and

b) The electronic control system of the welding equipment can be kept dry and operates properly.

11.3.2 Rail pullers must not be released until the EFB weld has cooled below 700 °F (371 °C).

11.3.3 It is the responsibility of the Supervisor/EFB unit operator on site to:

a) Determine that weather conditions are safe for personnel to properly perform their duties;

b) Ensure proper operation of the EFB welding unit, and

c) Determine that a quality weld can be made.

11.3.4 EFB welding is not permitted:

a) In heavy moisture or adverse weather conditions; and

b) When the rail temperature is below -10 °F (-23 °C).

Table 11-1: Requirements according to weather conditions

Rail Temperature and Weather Condition	Mitigation
Above 40 °F (5 °C) and Clear Weather	No cooling restrictions. A weld cooling cover is not required.
Above 40 °F (5 °C) with Wind, Rain, Sleet, or Snow Or Below 40 °F (5 °C)	Apply weld cooling cover immediately after shearing. Leave cover/blanket in place until the weld has cooled below 900 °F (483 °C).
Below -10 °F (-23 °C)	No electric flash butt welding is permitted.

11.4 Rail Wear Restrictions for EFB Welding

11.4.1 All replacement rails must be examined by trained and certified personnel prior to welding and must meet the requirements of the Metrolinx Track Standards for proper vertical offset size and type.

11.4.2 Maximum rail length for EFB welds to be completed with welding head only, with rail in plates and all anchors removed and spikes nipped, or with rail on concrete ties with clips and insulators removed:

a) Maximum unrestrained rail will be determined by CWR procedures; and

b) Maximum rail length for EFB welds to be completed with the welding head only should not exceed 20 tons (18 tonnes) of drag on the weld head.

11.4.3 Replacement rail must compensate for rail consumed in the EFB weld process. For closure welds in joint elimination operations, the replacement rail for the closure weld must be longer than the rail gap as follows:

Table 11-2: Additional Length to be Added to Replacement Rails

Welding Unit	Normal Rail Consumption	Overlap for Closure Weld	Replacement Rail Additional Length
Plasser K355 with Superjack, Chemetron	2.00 in	1.75 in	1.75 in

Welding Unit	Normal Rail Consumption	Overlap for Closure Weld	Replacement Rail Additional Length
Holland	1.50 in	1.25 in	1.25 in

11.4.4 The actual length of replacement rail – that is, how much existing rail must be replaced – is determined by specific location and according to the following requirements:

a) Follow all ultrasonic testing requirements found in the Metrolinx Track Standards (formerly GTTS);

b) Replacement (and existing) rail must be inspected for surface defects such as down sweep, surface bend, rail end droop, and rail end batter using a 36 in (914 mm) straight edge and a taper gauge. All surface defects must be removed by cropping the end of the rail, including rail ends that have been tapered by grinding to alleviate an offset condition;

c) Replacement (and existing in track) rail must be inspected for defects such as severe head checking or spalling, crushed heads, wheel burns, battered welds, welds that are kinked to gauge or field side, welds that are low or crowned outside of allowable tolerances and any surface bend condition in the rail joint. The length of replacement rail must be sufficient to remove these defects. If any of these conditions exist in the replacement rail, the replacement rail must be rejected;

d) Existing thermite welds must be eliminated (if possible);

e) Rail must be cut so that ties will not have to be moved to perform the weld – that is, the weld must be completed in an existing tie crib. Maintain a minimum distance of 4 in (101 mm) from the edge of tie to allow clearance for the weld shear dies.

11.4.5 Replacement rail should match as closely as possible to the proper metallurgy, weight/section, contour, height, and gauge face wear as the existing rail:

a) ***Note:*** Replacement rail of a different weight/section or wear pattern is permitted only if the maximum difference in height or width between replacement rail and existing rail does not exceed 3/16 in (5 mm);

b) If the height difference is greater than 1/8 in (3 mm) but less than 3/16 in (5 mm), EFB welds may be performed if a maximum of 1/8 in (3 mm) difference is confined to the base and the remainder (up to 1/16 in (1.5 mm)) is the vertical offset on the head. However, all welds must meet finished weld alignment tolerances.

Table 11-3: Maximum Allowable Vertical Rail Offset

Maximum Vertical Rail Offset	100 ARA or Smaller	115 RE	132 RE/136 RE
Up to 1/8" (3 mm) at the Base	Allowed	Allowed	Allowed
Up to 1/16" (2 mm) at the Ball	Not Allowed	Allowed	Allowed
Rails with greater than 5 mm vertical offset must have a transition rail cut to match vertical offset rail wear.			

11.4.6 Replacement rail must be the same rail type as the existing rail – that is, replace standard carbon steel rail with standard carbon steel rail and premium rail with premium rail per the Metrolinx Track Standards (Formerly GTTS) (metallurgy must be equal to or better than the existing rail).

11.4.7 Any joint or rail end that has been repaired by the electric arc welding process that is to be EFB welded must have the entire electric arc weld area plus an additional 4 in (100 mm) beyond, removed by saw cutting.

11.5 Preparation for EFB Welding

11.5.1 Obtain authority to occupy the track.

11.5.2 Site preparation:

a) Evaluate the general condition of the site:

i. Check for safety hazards;

ii. Check for fire hazards; and

iii. Firefighting equipment must be out and readily available.

b) Correct any situations which create a potential fire or safety hazard.

c) Determine if the weather is suitable for welding. Will the weld need to be protected with an umbrella or tent?

d) Joints intended to be welded in a signalled territory must be supported with a signals work plan methodology approved by Metrolinx or its designate:

i. In signalled territory temporary rail jumpers or cross-bonds must be installed prior to commencing joint removal.

11.5.3 Inspect rail to be removed and place match marks on the rail as required by the Metrolinx Track Standards (Formerly GTTS):

a) The maximum length of rail removed should not exceed the maximum length of rail that can be replaced, as per Rail Requirements above;

b) Cut marks should be centrally located in cribs so that ties will not have to be moved.

11.5.4 Install rail bypass cables or temporary bond wires:

a) The S&C Maintainer must be notified prior to the application of rail bypass cables or temporary bond wires;

b) Only Track, Welding, S&C, and other employees trained in the application of bonding and rail repair may install temporary rail bonds.

11.5.5 Cut rail at marks:

a) All rail ends to be welded must be cut with a rail saw. Torch-cut ends are not allowed to be welded; and

b) All saw cut rail ends must be dye penetrant tested.

11.5.6 Remove rail fasteners and anchors as required from the existing rail.

11.5.7 Remove existing rail.

11.5.8 Inspect and lay replacement rail, if necessary, securing as required to complete the weld.

11.5.9 Remove tie plates/pads at weld location(s) from ties on either side of the weld crib:

a) To provide a flat base for the EFB welding head, wood ties that are plate cut more than ½ in (12 mm) deep should be adze-leveled approximately 1 in (25 mm) on each side of the plate.

11.5.10 Remove spikes/clips from ties on each side of the weld crib:

a) For head welds: a minimum of 3 ties on each side; and

b) For closure welds with puller: a minimum of 5 ties on each side.

11.5.11 Remove (or not install) rail anchors/clips:

a) For head welds:

i. Do not install rail anchors or clips on the replacement rail. Allow free movement of the rail during welding; and

ii. Do not remove rail anchors/clips from the existing rail until after the free head weld is made.

b) For closure welds:

i. A rail puller is required if the rail temperature is at or below the PRLT;

ii. Remove all rail anchors/clips for a minimum of 150 ft (46 m) on each side of the weld;

Note: May need to offset lengths around fixed locations.

iii. Where there are no fixed structures such as bridges, switches and road crossings, remove rail anchors/clips for an equal distance on each side of the weld;

iv. Where there are fixed structures, do not remove rail anchors/clips closer than 200 ft (61 m) from the structure.

Note: It is recommended on concrete and wood ties with elastic fasting systems in curves 2° and above to install destressing/chording clips on every 15th tie to ensure the safe travel of the EFB welding equipment vehicle and to prevent rail cant or rollover. Double-flanged wheels may also be used on the EFB equipment.

11.5.12 Remove ballast (for the installation of shears, alignment jacks, weld heads/pullers, and spreader bars):

a) Remove 6 in (152 mm) of ballast from under rail at weld location to provide clearance for shear;

b) Dig holes on each side of the weld crib for the rail alignment jacks:

i. For pancake jacks: 7 in (178 mm) deep in the first crib on each side of the weld crib;

ii. For hydraulic track jacks: 3 in (76 mm) deep in the third crib on each side of the weld crib.

c) If a spreader bar is used for the closure welds, remove 4 in (100 mm) of ballast in the third tie crib, each side of the weld crib.

11.5.13 Preparing rail ends:

a) Flash butt welds must be a minimum of 3 ft (914 mm) from an existing EFB weld and a minimum of 6 ft (1.8 m) from a thermite weld;

b) To prepare both the existing and replacement rail ends for EFB welding:

i. Ensure the DP test is completed and marked.

ii. Inspect rail end cuts for squareness. Cuts must not be more than 1/8 in (3 mm) out of square;

iii. Remove all dirt, grease, mill scale and rust on both rail end faces down to bright metal;

c) Where the welding electrodes and rail pulling pads contact the rail:

i. Clean all dirt, grease, mill scale, rust and raised lettering (branding) down to bright metal, flush with the web surface.

d) Remove all steel overflow (lip on the ball of the rail) by grinding:

i. From the side of the rail head if the lip is greater than 1/8 in (3 mm);

ii. From under the head of the rail on both the gauge and field sides, for a distance of 6 in (152 mm) from the rail end.

e) When a weld is cut for re-weld, cut using an approved abrasive rail saw;

i. Torch cutting of the rail is allowable, provided that the finished rail end surface is cut with an approved rail saw.

Note: All saw cut rail end slivers must be dye penetrant tested.

11.5.14 General Housekeeping:

a) During the EFB welding process, a strong magnetic field is created around the welding head. This field may attract any nearby metal objects into the welding system, shorting out the system, damaging the welding head and causing a defective weld. Therefore, all anchors, spikes, plates, clips, etc., that are removed during preparation must be moved to a safe distance from the welding area.

11.6 Rail Alignment

11.6.1 New rail should match as closely as possible to the parent rail in section/weight and vertical and horizontal wear so that differences in rail height and rail head width do not exceed 1/8 in (3 mm).

11.6.2 Prior to welding, the parent and new rails must be vertically aligned at the head of the rail so that when the rail has returned to ambient temperature, any difference in height (within the allowable tolerance) is confined to the base.

11.6.3 The rail must also be horizontally aligned so that any difference in rail head width is within the allowable tolerance. In-track welder head clamps the rail in the web holder to align the rails; therefore, the welder head shims must be checked and adjusted to prevent horizontal twist or offset.

11.6.4 The rail webs must also be aligned horizontally, not exceeding a maximum of 0.040 in (1 mm) offset.

11.7 Performing the Weld

11.7.1 Refer to the manufacturer's operating manuals for specific instructions on the safe operation of electric flash butt welding equipment. Generally, the procedure is as follows (actual procedures may vary slightly depending on the equipment used and the type of weld being done):

a) Attach the welding head and, if necessary, a rail puller;

b) Perform the weld;

c) Remove welding head and rail puller;

d) Shear off the extruded metal; and

e) Finish grind the weld.

11.7.2 Defective welds:

a) A defective weld must be removed and the rail re-welded. The removal of rail to remove a defective weld will result in the need to insert a rail plug in order to maintain the correct PRLT.

b) A weld must be considered defective if any of the following occurs:

i. Clamp or puller slippage during any stage of the welding process, including holding time;

ii. Interruption of platen travel or current during the progressive final flashing period prior to upset;

iii. Upset current of less than one (1) second duration;

iv. Upset distance of less than ½ in (13 mm) or greater than 1 in (25 mm);

v. Upset pressure not conforming to the type of weld and manufacturer's equipment; and

vi. Holding time of less than 9 seconds.

c) Rejected welds must be saw cut through the weld centreline and re-welded. If the weld is rejected a second time, the rail must be cut 4 in (100 mm) on both sides of the weld centreline before re-welding. An additional plug rail will be required to meet CWR rail temperature requirements.

11.7.3 Welding machine electrodes:

a) Proper-sized electrodes must be used for the rail section being welded. See the manufacturer's operating manual for the proper electrode size;

b) Welding head electrodes must be inspected after each weld to ensure the electrode makes complete contact with the rail. The electrode surface must be kept clean and smooth; and

c) If the rail shows any evidence of electrode burns following welding, the weld must be rejected. Electrode burn evidence is defined as any physical displacement of carbon steel rail material, burning or arcing, under the electrode area.

11.7.4 Hydraulic rail pullers:

a) When a hydraulic rail puller is used in conjunction with the EFB welding head, the pressure must be maintained on the completed EFB weld until the weld has cooled to below 700 °F (371 °C).

11.7.5 Welding machine clamping and upset removal:

a) The clamp area in the web of the rail must be inspected on every weld for gouging or slippage. Any gouge or slip marks into the parent or plug rail metal must be cause for the weld to be rejected; and

b) Any clamping by the welding machine in the web of the rail during the welding cycle must not distort the physical dimensions of the rail.

11.7.6 Post weld crown check:

a) Immediately following the removal of the welding head, check the crown as follows:

i. Place a 36 in (914 mm) cut-out straight edge on the top surface of the rail with the gap (cutout) centred over the weld;

ii. Insert a taper gauge between the straight edge and the rail surface; and

iii. The gap between the straight edge and the rail crown should be between 0.060 - 0.120 in (1.5 - 3.0 mm) combined.

11.7.7 Weld data recorder:

a) The recorder must be operational and accurate to monitor the following welding parameters:

i. Welding time;

ii. Welding current;

iii. Welding force, including upset force; and

iv. Platen travel (rail consumption, displacement).

b) A “dry run” test weld must be made and documented at the beginning of each welding shift.

c) The following information is inputted to the EFB welding chart document from the weld data recorder:

i. Date;

ii. Location; and

iii. The consecutive weld number: corresponding to the weld recorder number, welder unit number (truck), marked on the gauge side web of the rail, must be within 3 ft (914 mm) of the weld with 2 in (51 mm) high lettering with a white paint stick, right side up.

11.8 Shearing

11.8.1 Immediately after removing the welding head, the excess metal extruded around the weld joint during the welding process must be sheared off.

11.8.2 Shear dies must be maintained to:

a) Provide a clean cutting edge to avoid smearing or dragging of the weld upset material; and

b) Not cut or tear the parent carbon steel rail.

11.8.3 **Safety critical rule:** The extruded metal and rail ends will be very hot – use extreme caution. Do not spray rail or weld with water.

11.9 Finish Grinding

11.9.1 Remove (by grinding) any remaining metal extruded from around the weld and from the running surface, from the gauge and field sides of the head and from the web collar and base:

a) All sharp edges and burrs must be removed;

b) ***Note:*** Use caution when grinding at ambient temperature not to overheat the rail (called bluing the rail, which causes a rapid heating and cooling effect).

c) Once the rail has cooled to ambient temperature, the alignment of the rail ends must be checked, and the rails ground to taper or gradually introduce any acceptable offset. Tapers must be ground at a rate of 0.020 in (0.5 mm) per foot. (**Example:** 2 mm offset requires a 48 in long taper.)

d) ***Note:*** Maximum vertical offset in the ball must not exceed 0.07 in (2 mm).

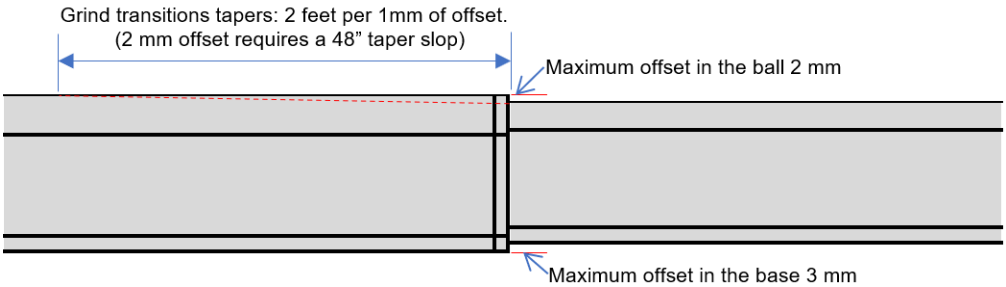


Figure 11-1: Maximum Vertical Offsets for EFB Welds

Table 11-4: Offsets and Taper Grinding Lengths

OFFSET			GRINDING TAPER LENGTH (T) INCHES			
X (inches)	Fractional Equivalent For Maximum	MM Equivalent For Maximum	VERTICAL OFFSET	HORIZONTAL OFFSET		
				GAUGE		FIELD
				FACE	CURVE WEAR, FLOW LIP	WEAR, FLOW LIP
0.01			6	6	6	6
0.011 - 0.020		0.50 mm	12	12	12	6
0.021 - 0.030	1/32	0.76 mm	18	18	18	6
0.031 - 0.040		1.01 mm	24	24	24	6
0.041 - 0.050		1.27 mm	30	30	30	6
0.051 - 0.060	1/16	1.52 mm	36	36	36	6
0.061 - 0.080		2.03 mm	48	42	36	6
0.061 - 0.125	1/8	3.17 mm			42	6
0.126 - 0.188	3/16	4.77 mm			42	
0.189 - 0.250	1/4	6.35 mm			48	
0.251 - 0.313	5/16	7.95 mm			48	
0.314 - 0.375	3/8	9.52 mm			72	
0.376 - 0.500	1/2	12.7 mm			72	

11.9.2 Finish grinding of the running surface, gauge, and field side:

a) Perform finish grinding as follows:

Table 11-5: Weld Grind Tolerances

Measurement	Dimension	Tolerances for EFB Welds
Crown: Peak of the rail at the weld	A	0.060 in (1.52 mm)
Vertical Offset: Vertical difference on the rail head	C	0.060 in (1.52 mm)
Dip Camber	E	0
Horizontal Offset: Horizontal difference on side of the rail head	B	0.040 in (1.01 mm)
Indent: Kink to field side	D	0.030 in (0.76 mm)
Intent: Crown inward (peak) toward track centre	D	0.60 in (1.52 mm)

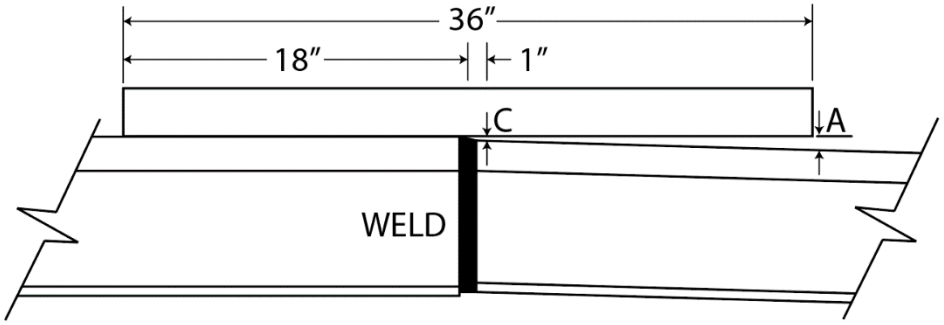


Figure 11-2: Vertical Weld Grind Tolerances

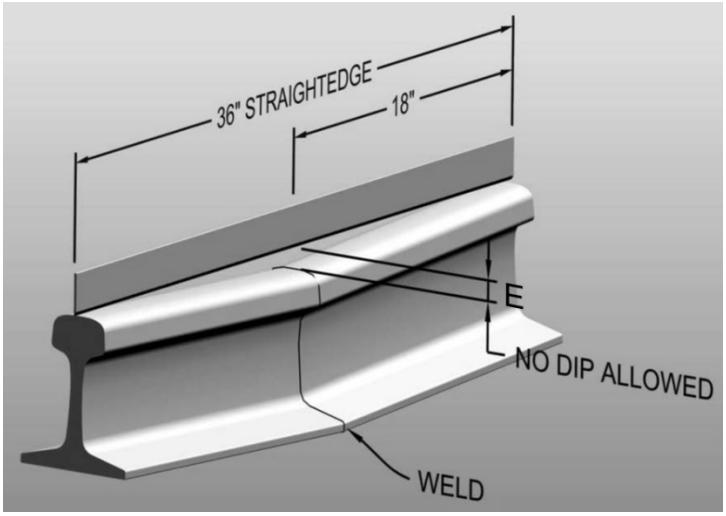


Figure 11-3: Dip Camber Tolerance

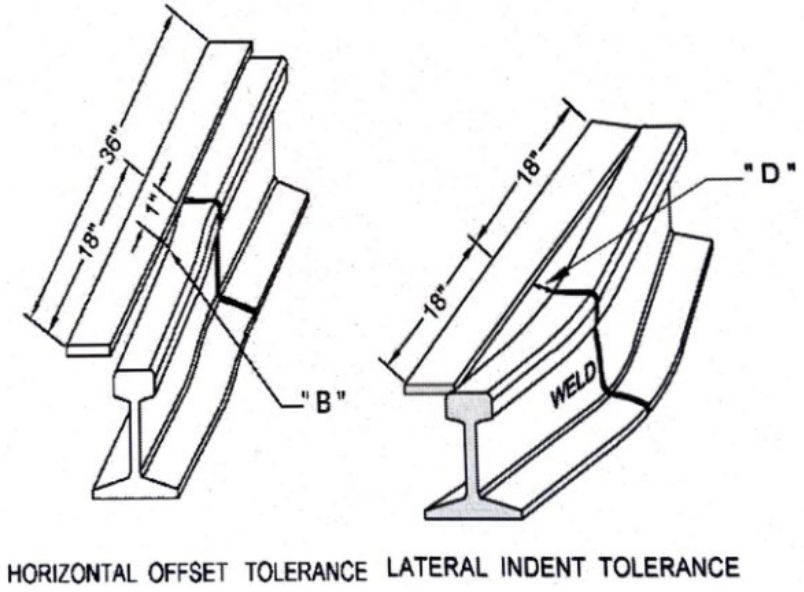


Figure 11-4: Horizontal Weld Grind Tolerances

11.9.3 Web collar and base:

a) Finish grind the web collar and base as follows:
   i. Grind rail web and fillets smooth on both sides of the rail to within 1/16 in (1.6 mm) of the original contour;
   ii. Do not undercut rail metal;
   iii. Do not introduce shear drag; and
   iv. If shear gouging into rail metal occurs, the weld is defective and must be removed from track.

b) For roller line or out-of-track welding, finish grind base faces as follows:
   i. Grind rail base faces flush;
   ii. The edges of the rail base AND the rail base must be ground to ensure that there are no stress risers at the edges and to allow rail to fit into the tie plates.

c) A slight 1/16 in (1.6 mm) radius can be applied to both the top and bottom of the rail base edge, so no sharp edges remain.

11.10 Traffic Restrictions for EFB Welding

11.10.1 Do not permit train traffic across a completed EFB weld until:

a) The running surface and gauge face are rough ground to within 0.030 in (0.76 mm);
b) The weld has cooled below 700 °F (371 °C);
c) All wedges, blocks and jacks have been removed;
d) The weld has been supported by a tamped tie on each side; and
e) Plug/glue and spike or clip ties.

11.11 Post Weld Inspection and Marking

11.11.1 Post-weld inspection includes the following:

a) Visual inspection:
   i. All finished welds must be visually inspected for imperfections and discontinuities that might compromise the integrity of the weld.

b) Finished alignment check:
   i. All finish grinding tolerances must be measured at a temperature at or below 200 °F (93 °C); and
   ii. Vertical and horizontal alignment must be in compliance (reference Weld Grinding Tolerance Table 11-5 above).

11.11.2 Weld data recording:

a) The final step in the EFB welding process is to mark the weld information on the rail and properly record all welding details on a welding report;

b) The employee in charge of the in-track EFB welding unit is responsible for ensuring that all EFB welds are correctly marked and identified on the web of the rail with a paint stick marker;

c) Each weld must be labelled in permanent white paint marker, on the gauge side of the rail within 3 ft (914 mm) of the weld with the following:

i. Identification of welding crew welder (Welder number, company name and truck number);

ii. Date of weld (DD-MM-YY);

iii. Consecutive weld number;

iv. Length of rail added or removed;

v. Rail temperature at the time of welding;

vi. Method of controlling rail: hydraulic rail expander (E) or rail heater (H); and

vii. Dye Penetrant test completed on both rail ends and indicated with the letters DP;

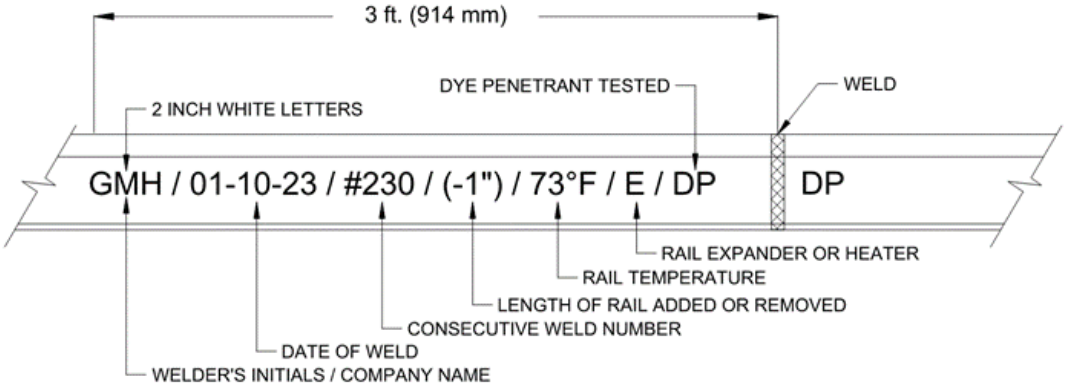


Figure 11-5: Weld Information Marking

12 Miscellaneous Weld Repairs

12.1 Switch, Frog, and Diamond Crossing Plates

12.1.1 Often, welded stops, elastic fastener shoulders, and blocks for rail braces are found missing, or their weldments cracked. These items can be field repaired by welding.

a) When one or more stops, elastic fastener shoulders or brace blocks are found missing or their weldment cracked, inspect the entire area for others that may also require repair or replacement.

12.1.2 To remove existing stops, elastic fastener shoulders, or braces blocks:

a) Use air carbon arc equipment to remove the cracked welds holding the stops, shoulders, or blocks in place:

i. **Safety critical rule:** Avoid arcing to or cutting the rail with the air carbon arc equipment. Arc strikes or burns are strictly prohibited.

b) After the item has been removed, remove the remaining weld metal by grinding flush to the plate surface.

12.1.3 Follow these steps to replace and weld each item:

a) Lightly grind the plate to remove rust or mill scale where the weld metal will be deposited;

b) Locate the position of the item to be welded;

c) Mark the location of the item;

d) Apply the work/ground clamp to the plate;

e) Place the item on the plate;

f) Use a 1/8 in (3 mm) 7018 welding electrode for welding;

g) Tack weld the item in position;

h) Weld one pass on each of the three sides of the item;

i) ***Note:*** Do not allow the welding electrode to arc or weld to the base of the rail.

j) After completing one pass, weld a second pass so as to leave a ¼ in (6 mm) fillet weld on 3 sides of the item (wherever possible);

k) Remove any weld metal that might interfere with the insertion of the elastic fasteners;

l) Install all elastic fastener clips after the shoulders have been welded in place; and

m) Install all cut spikes after the stops have been welded in place.

12.2 Track Components Not to Be Repaired by Welding

12.2.1 The following items are not to be repaired by welding:

a) Connecting or adjusting rods for:
   i. Switch points;
   ii. Moveable frog points (MPF); and
   iii. Switch stands or switch machines.

b) Adjustment clips for:
   i. Switch points (switch clips);
   ii. Moveable frog points (MPF); and
   iii. Switch stands or switch machines.

c) Switch point guards or switch point protectors;

d) Switch point stops;

e) Guard rails or adjustable guard bars;

f) Bolts or nuts;

g) Joint bars; and

h) The following castings:
   i. Toe and heel blocks on frogs;
   ii. Housings on spring frogs;
   iii. Floating heel blocks;
   iv. Rail braces; and
   v. Shoulders on concrete ties.

13 Air Carbon Arc Metal Removal

13.1 Overview

13.1.1 The air carbon arc method is used for removing defects in metal before building-up. It is also used for removing existing welds in order to disassemble parts so that one or more of the components can be repaired or replaced. Carbon arc metal removal and air slicing are processes generally used to remove large defects in manganese castings.

13.1.2 The use of air carbon arc gouging, cutting, or slicing is prohibited on any carbon steel rail or rail components. Rapid heating and cooling of the carbon steel rail will cause damage to the grain structure and possible fracture.

13.2 Equipment

13.2.1 All Welders must be trained and certified in the safe operation and proper setup of the air carbon arc equipment.

13.2.2 The exact air quantity and pressure requirements vary with the specific torch used. These can range from 80 to 100 PSI and 26 to 33 CFM for standard torches:

a) All electric track welding crews must have an air compressor with a minimum of 30 CFM (0.85 CMM) output and the ability to adjust from 4 psi to 120 psi (28 to 827 kPa).

13.2.3 **Safety critical rule:** Use only compressed air. The use of oxygen or any other compressed gases is strictly prohibited; they can cause explosions, resulting in serious personal injury or death.

13.2.4 All electric welding power sources must be capable of producing a minimum of 400 amps of output to a distance of 150 ft (46 m) with a 100% duty cycle.

13.2.5 Use only fully insulated air carbon arc torches.

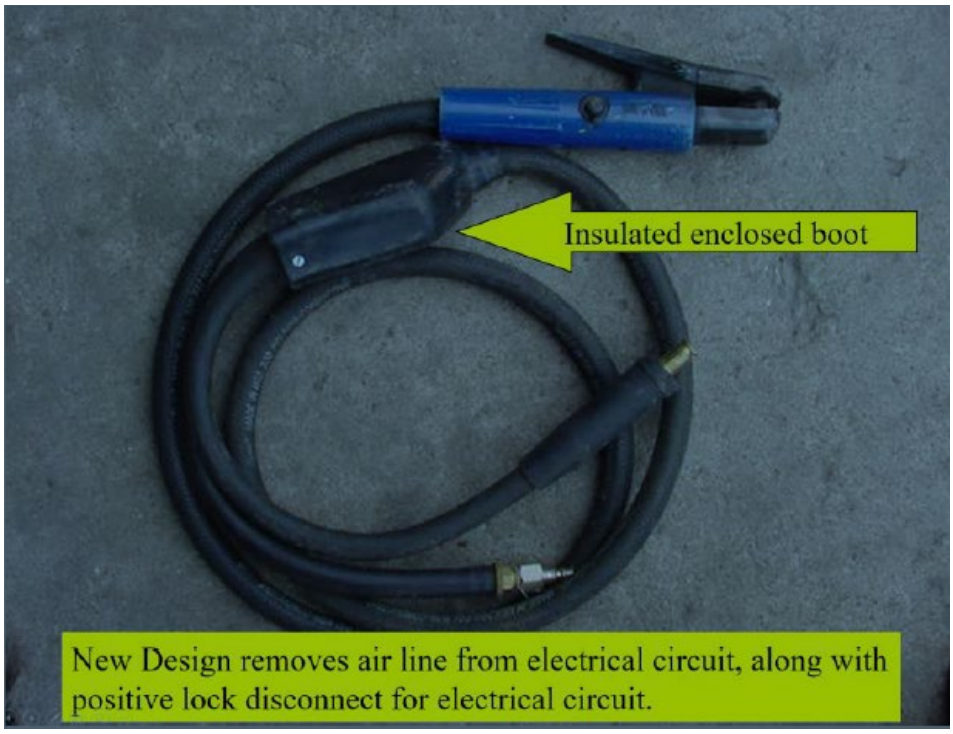


Figure 13-1: Example of a Carbon Arc Torch

13.3 Air Carbon Arc Procedures

13.3.1 Follow this procedure for air carbon arc procedures metal removal:

a) Select the amperage setting from the table below. The amperage needed depends upon the carbon electrode diameter or size. The best results are usually obtained when the maximum amperage is used;

Table 13-1: Operating Parameters for Carbon Electrodes

Electrode dia/size (inches)	Range (amps)	Comments
1/4	300 - 400	This is the largest carbon electrode usable when only meeting the minimum required amperage welding power source.
5/16	350 - 450	
3/8	450 - 600	

b) Use round or flat carbon electrodes, matched to the size of the welding power source;

c) Use spark shields for this Hot Work process, as the high air pressure will blow away the defective material being removed;

d) Assign a Fire Watch to watch both the surrounding area and the worker;

e) Use a minimum of a No. 12 lens shade for ¼ in (6 mm) carbons when air carbon arc gouging or cutting. The use of a larger diameter electrode and higher amperage will require the use of darker lens shades;

f) Wear a respirator when welding or cutting on manganese track components; and

g) Wear hearing protection as this process is very loud.

14 Weld Repair of Manganese Track Components

14.1 Overview

14.1.1 Austenitic Manganese Steel (AMS) is steel with a high level of manganese alloying that has a substantially austenitic structure and is characterized as having a high work hardening rate and being non-magnetic or only slightly magnetic.

14.1.2 Components or parts of components made of austenitic manganese steel, commonly referred to as manganese, are one-piece, poured castings.

a) These castings can be part of a track component such as:

i. Solid Self-Guarded Manganese (SSGM) frogs;

ii. Jointless Boltless Manganese (JBM) frogs;

iii. Solid manganese diamond crossings; and

iv. Lap beam crossings

b) Or they may be part of a component, as in:

i. Rail Bound Manganese (RBM) frogs;

ii. Welded Heel Manganese (WHM) frogs;

iii. Spring rail frogs;

iv. Reversible insert diamond crossing;

v. One-Way Low Speed (OWLS) frogs and diamond crossings;

vi. Switch point guards/protectors. (Not to be repaired by welding.);

vii. Guard rail bars. (Not to be repaired by welding.);

viii. Sliding joints; and

ix. Mitre rails and bridge castings.

14.1.3 New manganese castings are generally Explosive Depth Hardened (EDH) to increase hardness to 370 to 380 Brinell Hardness Number (BHN). Weld-repaired areas are much softer and usually are only around 200 to 250 BHN. The castings will work harden over time from impact loading of the rolling wheels to around 500 to 550 BHN.

14.1.4 Prolong the life of manganese components by grinding, slotting, and monitoring them. Schedule preventive grinding and slotting intervals to remove plastic flow and lip:

a) Keep a log of grinding and welding work in case of a warranty claim;

b) New installations or completed weld repairs must be ground within the first 2 months from installation or repair;

c) Thereafter, grind before the metal flow reaches 1/6 in (1.5 mm); and

d) Monitor for flow and lips for additional preventive grinding until fully work hardened:

   i. Grinding should be the primary maintenance technique for manganese castings. An effective grinding program will delay the need for repair welding and reduce the amount of welding required; and

   ii. If welding is not needed, grind to prevent premature failures and postpone welding repairs.

14.2 Requirements For Welding Manganese Track Components

14.2.1 Only those Welders who have been trained and certified are allowed to make weld repairs on manganese track components.

14.2.2 Welding, grinding, arc-air gouging and cutting are considered Hot Work, and all safety, fire risk, and PPE requirements must be followed.

14.2.3 Use the Flux Cored Arc Welding (FCAW) method using a wire feed for making weld repairs on manganese:

a) The recommended diameter for flux core wire is 5/64 in (2 mm);

b) Wire is the preferred method due to the following:

   i. More material being applied faster; and

   ii. Less heat input into the manganese casting.

14.2.4 Use the Shielded Metal Arc Welding (SMAW) method using stick electrode, only when making minor repairs, touch-ups, or if the FCAW wire feeder is inoperative:

a) The maximum diameter electrode allowed is 3/16 in (5 mm).

14.2.5 Welders must:

a) Wear a respirator while welding, grinding, or carbon arc air gouging/cutting on manganese track components; and

Figure 14-1: Types of Respirators
Courtesy 3M and Pandrol

b) Control and measure the heat input into the manganese casting using the following:

   i. Compressed air (the preferred method); and

   ii. Temperature measuring tools such as temp sticks and laser temperature guns.

14.2.6 Welders are:

a) Only allowed to use welding material specifically designed for welding manganese steel;

b) Required to have all the necessary tools and equipment prior to starting any repair welding work.

14.3 Inspection Prior to Repair Welding of Frogs and Diamond Crossings

14.3.1 Follow the procedure below when repairing a frog or diamond crossing:

a) Identify metal flow or bulging areas in the flangeway walls;

b) Inspect for marks or cracks in the manganese casting;

c) Inspect for offsets in the wheel running surfaces, (including all mating surfaces);

d) Inspect the following for excessive metal flow:

   i. Joints;

   ii. Heel of manganese inserts; and

   iii. Mating surfaces between rail and manganese casting.

e) Inspect all bolts and washers:

   i. Replace, renew, or tighten bolts as necessary before welding.

f) Inspect the condition of the following:

   i. Gauge and alignment of the frog; and

ii. Welds on frog gauge plate, plate stop blocks, elastic fastener shoulders.

g) Inspect for broken or missing plates and fasteners;

h) Inspect the surface, tie, and subgrade conditions;

i) Check both the frog guard check gauge and guard face gauge to ensure compliance with Transport Canada Rules Respecting Track Safety and the Metrolinx Track Standards (Formerly GTTS) requirements for the Class of Track involved; and

Table 14-1: Guard Check and Guard Face Gauge by Class of Track

Class of Track	Minimum Guard Check Gauge (A)	Maximum Guard Face Gauge (B)
1	54 1/8 in (1,375 mm)	53¼ in (1,352 mm)
2	54¼ in (1,378 mm)	53 1/8 in (1,349 mm)
3,4	54 3/8 in (1,381 mm)	53 1/8 in (1,349 mm)
5	54½ in (1,384 mm) [c]	53 in (1,346 mm)

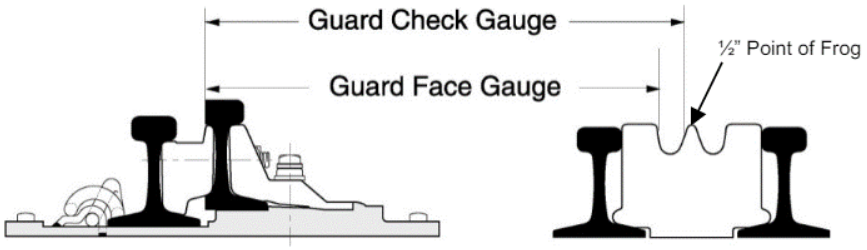


Figure 14-2: Measurement of Guard Check and Guard Face Gauge

j) Protect train movements with the proper speed restriction, following Transport Canada Rules Respecting Track Safety and the Metrolinx Track Standards (Formerly GTTS) requirements:

i. Flangeway Depth – must not be less than 1 3/8 in (35 mm) for Class 1 Track; or 1½ in (38 mm) for Class 2 through 5 Tracks;

ii. If the frog point is chipped, broken, or worn more than 5/8 in (16 mm) down and 6 in (152 mm) back, the operating speed over frog must be restricted to 10 mph (16 km/h) until repaired or replaced;

iii. Tread Wear: If the tread portion of any frog or diamond casting is worn down more than 3/8 in (9.5 mm) below the original contour, the operating speed over the frog or diamond casting must be restricted to 10 mph (16 km/h) until repaired or replaced.

14.3.2 Repairs to Solid Self-Guarded Manganese (SSGM) frogs require the following additional inspections:

a) Check the guarding face, if it is worn more than ¼ in (6 mm), the speed must be restricted to 10 mph (16 km/h) until repaired or replaced. If repairs are made to a self-guarded frog without removing it from service, the guarding face must be restored before rebuilding the point.

b) Follow this procedure to check the wear on a self-guarded frog:

i. Place the flangeway gauge at the actual 5/8 in (16 mm) point, with the side stamped "SG" toward the guard. (See Figure 14-3 below.);

ii. If the clearance between the guard and the gauge exceeds ¼ in (6 mm), the frog should be either restored or replaced.

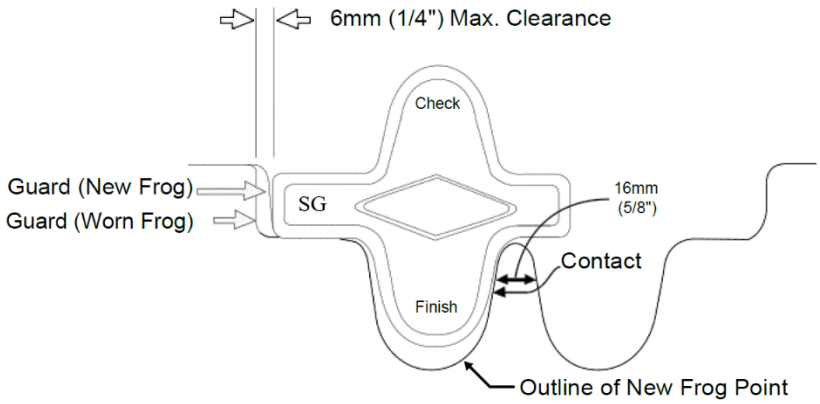


Figure 14-3: Measuring Guarding Face Wear on an SSGM Frog

14.4 Preparing For Welding on Frogs and Diamond Crossings

14.4.1 Ensure that there is positive on track protection in place prior to performing any welding or preparatory work to frogs and diamond crossings.

14.4.2 Clean areas to be welded of all oil and grease by scraping and wire brushing.

14.4.3 Remove overflow metal from casting by grinding, including slotting of all mating surfaces between casting sections and binder rails.

14.4.4 Remove any cracks and chips, defective or worn metal by grinding or air carbon arc torch:

a) When removing large portions of the casting, use the air carbon arc torch equipment to minimize preparation time;

b) After using the air carbon arc equipment to remove damaged or broken material from the casting, dress the area smooth and clean by grinding; and

c) Don't use an oxy/fuel gas cutting torch on manganese castings to remove defective material.

14.4.5 Remove by grinding a minimum of ¼ in (6 mm) of work-hardened material in areas of the casting requiring build-up repair.

14.4.6 Never apply preheat or post-heat to any manganese castings:

a) **Exception:** When the ambient air temperature is below 0 °F (-18 °C), to help control thermal shock to the casting, use a torch and a soft flame to *warm* the casting work area to 100 °F (38 °C). This is not considered preheating.

14.5 Repair Welding of Manganese Frogs and Diamond Crossings

14.5.1 **Safety Critical Rule:** Control the heat input into manganese castings. Manganese steel should never exceed a temperature of 500 °F (260 °C).

14.5.2 Control the heat input into the casting by:

a) Staggering weld beads from the point to the wing, then to the opposite wing and then back to the point;

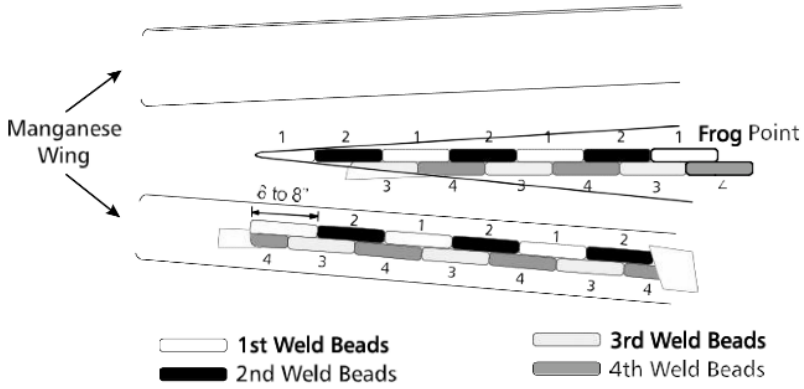


Figure 14-4: Example of Staggering Weld Beads in Point and Wing Build-up

b) Using 5/64 in (2 mm) diameter wire (wire is the mandatory method):

i. With stringer bead width not exceeding 5/8 in (16 mm); and

ii. With stringer bead length not exceeding 14 in (355 mm).

c) Using 3/16 in (5 mm) diameter electrode (per exceptions in 14.2above):

i. With stringer bead width not exceeding 5/8 in (16 mm); and

ii. With stringer bead length not exceeding 8 in (203 mm).

14.5.3 Run all stringer beads parallel to the direction of wheel travel:

a) Alternating parallel travel direction from toe to heel and then heel to toe is acceptable. This method also helps reduce internal stress.

Exception: Welding across the casting is allowed when filling cracks, but in no case closer than 1 in (25 mm) to the finished running surface.

14.5.4 Clean slag with a needle scaler or a chipping hammer and wire brush, after welding each bead:

a) Clean slag from where the bead starts toward finish (cold to hot);

b) Peen bead using a 2 lb (.9 k) ball peen hammer;

c) Use 3 to 4 blows per inch of weld bead;

d) Peen from the bead finish towards start (hot to cold) to reduce stress;

e) Monitor the temperature of the casting between weld beads using:

i. A laser temperature gun or

ii. A temp stick.

14.5.5 Take temperature measurements:

a) On the flangeway wall ¼ in (6 mm) below the weld bead, or along the side of the weld bead ½ in (12 mm) away;

b) Ensure that the inter-pass temperature is 375 °F (190 °C) or below before starting the next weld bead;

c) Blowing compressed air over the weld area is the preferred method to control heat input.

Note: Never use oxygen as a substitute for compressed air.

14.5.6 Use flangeway blocks, while building up flange walls on both wing and point areas. Carbon or copper blocks are acceptable.

Figure 14-5: Carbon Block Flange Guide and b) Copper Flange Guide
Courtesy Industry Railway Suppliers and Track Weld Inc.

14.5.7 If welding operation is interrupted for a train movement:

a) Grind the flangeway opening to 1 7/8 in (48 mm) width prior to train movement;

b) Ensure the proper TSO is in place prior to allowing any movements;

c) Grind the weld area to remove work-hardened areas after train movement has passed and prior to resuming any welding.

14.5.8 Continue welding, repeating the steps above until the heights of the completed weld areas are slightly higher than the required finished dimensions of the casting.

14.5.9 Using a straight edge and required gauges, finish grind and slot the casting to the proper dimensions, slopes, angles, and radii for the type of component welded.

14.5.10 When performing finish grinding, leave smooth flangeway walls with no vertical or horizontal undercut or ghost lines that will give Track Inspectors the impression of an existing crack.

14.5.11 Inspect and regrind the manganese castings the first week after repair:

a) Grinding and slotting flow and restoring radii;

b) Additional grinding as required.

14.5.12 The main line running rail through any flange bearing or One-Way Low Speed (OWLS) frog or diamond crossing will develop a groove (from wheels) across the head of the rail. This cannot be repaired by welding.

14.6 Weld Repairs for Out of Track Frogs and Diamond Crossing Inserts

14.6.1 When making weld repairs on frogs and diamond crossings out of track, they are subject to distortion. This occurs when the weld area cools and shrinking forces cause the workpiece to be pulled towards the weld repaired area.

14.6.2 Place the component in a jig or a strongback, with the centre slightly shimmed up and the outside ends held down and secured in place.

Figure 14-6: Diamond Crossing Insert Being Repaired in a Strongback Jig
Courtesy CN Training

Figure 14-7: Frogs Being Repaired in a Strongback Jig
Courtesy CN Training

14.6.3 Place ties or blocking under the centre of the frog and let the toe and heel rails hang down, if a strongback jig is not available.

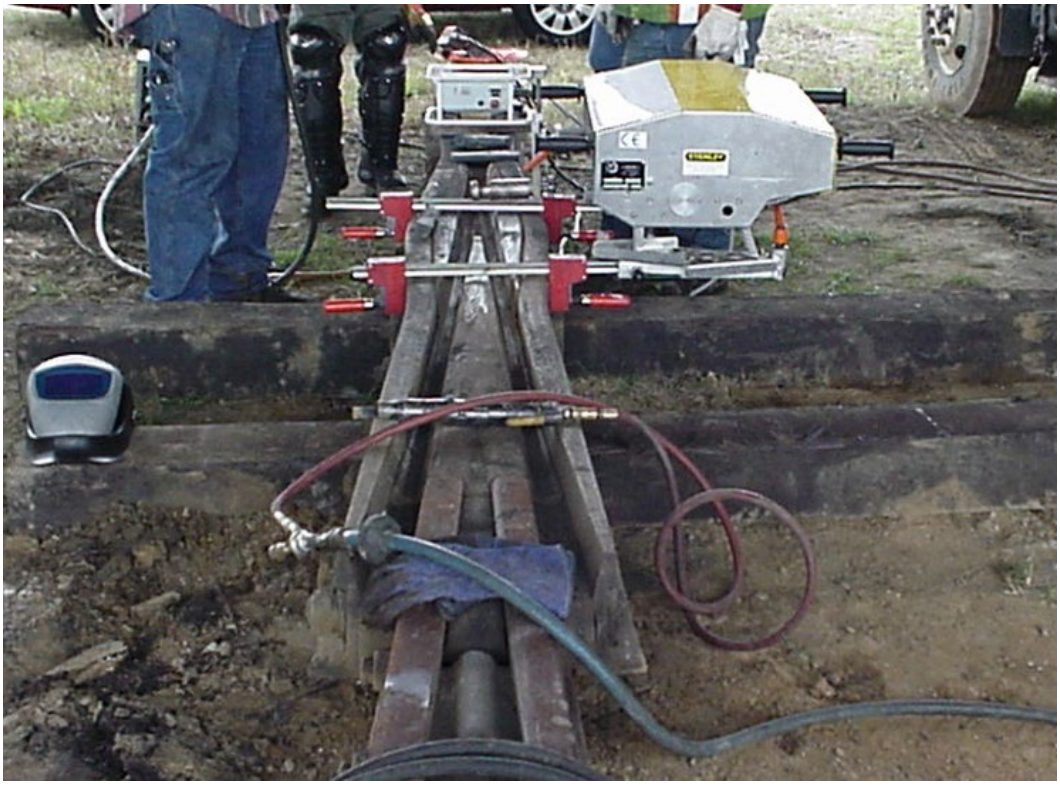


Figure 14-8: Frog Being Repaired Supported on Ties
Courtesy CN Training

14.6.4 Never weld inside an enclosed building without proper ventilation.

14.6.5 Follow all safety rules appropriate for the type of component being repaired.

14.6.6 Follow the welding and grinding procedures (as applicable) outlined in Section 14.5.

15 Storage of Welding Consumables, Gasses and Oxygen

15.1 Storage of Abrasive Wheels, Blades, Disks, and Stones

15.1.1 Protect all abrasives while awaiting use.

15.1.2 Arrange storage by size and type to allow ease of item selection:

a) Without disturbing other items;

b) Without damaging other items;

c) With a minimum of handling;

d) Do not stack directly on floors, place on pallets; and

e) Rotate stock frequently using oldest items first.

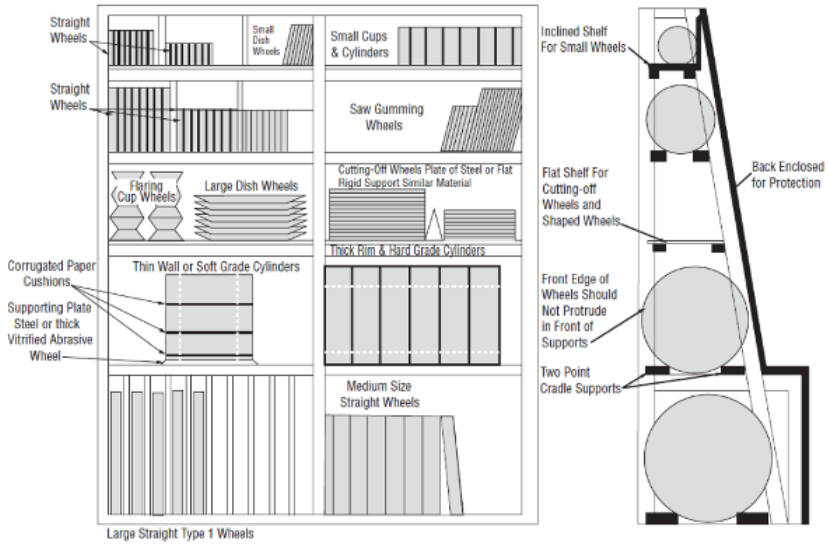


Figure 15-1: Example of Proper Grinding Wheel Storage
Courtesy Norton Abrasives

15.1.3 All abrasives are porous and will absorb moisture:

a) Store in a dry area not subject to extreme temperatures, protecting from water, oil, or solvent damage;

b) Do not transport abrasives attached to a tool. Remove abrasives from the tool and store protected from weather;

c) Protect from freezing, as freezing may damage abrasives.

15.1.4 Store thin bonded wheels, saw blades, slotting, and cutoff wheels flat on a firm, level, dry surface, protected from the weather. Ensure that they are:

a) Kept in original manufacturer packaging or boxes;

b) Kept from bouncing or extreme vibration; and

c) Stored without blotters between wheels.

15.1.5 Store straight stones (8 x 1 x 5/8 in / 203 x 25 x 15 mm) laid flat on a firm, flat, dry surface and protected from the weather. Ensure that they are:

a) Kept in original manufacturer packaging or boxes; and

b) Kept from bouncing or extreme vibration.

15.1.6 Stack straight cup wheels on flat sides with a cushioning material between them. Store on a firm, flat, dry surface, protected from the weather. Ensure that they are:

a) Kept in original manufacturer packaging or boxes; and

b) Kept from bouncing or extreme vibration.

15.1.7 Store flared cup wheels in boxes, bins, or drawers. Do not rest or fit one inside the other. Use a layer of cushioning material between each layer of wheels. Store on a firm, flat, dry surface, protected from the weather.

15.1.8 It is critical to rotate stocked/stored abrasives. Use all abrasive wheels, blades, disks, and stones within two (2) years from the manufacture date.

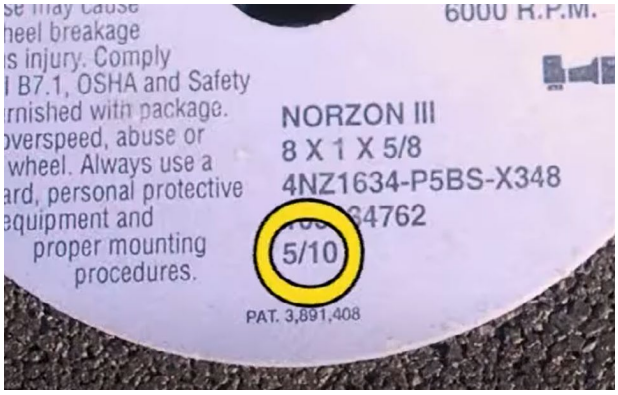


Figure 15-2: Abrasive Wheel Manufacture Date
Courtesy Industrial Railway Suppliers

15.1.9 Visually inspect, prior to use, all new or used abrasive wheels, blades, disks, and stones, looking for imperfections:

a) Cracks;

b) Nick or chips;

c) Moisture damage; and

d) Freezing damage.

15.2 Storage of Thermite Weld Kits

15.2.1 Protect all welding kits, moulds, charges, crucibles, packing sand, mud, paste, and igniters while awaiting use.

15.2.2 Arrange storage by size and type to allow ease of item selection:

a) Without disturbing other items;

b) Without damaging other items;

c) With a minimum of handling;

d) Do not stack directly on floors, place on pallets; and

e) Rotate stock using oldest items first.

15.2.3 Store all thermite consumables in a dry, climate-controlled environment protecting from; extreme heat, water, humidity, and freezing.

15.2.4 Store and handle all weld moulds and crucibles with extreme care. These are very fragile and will absorb moisture easily.

Figure 15-3: Manufacture Date on Thermite Consumable Box

15.2.5 When transporting thermite consumables:

a) Store in a flat, dry, well-supported area protected from the weather;

b) Keep in original manufacture packaging or boxes; and

c) Keep from bouncing or extreme vibration.

15.2.6 Rotate inventory stock frequently as all thermite welding consumables have a defined shelf life as follows:

a) Moulds and crucible, two (2) years from manufacture date;

b) Weld charge bags, five (5) years from manufacture date; and

c) Packing sand or mud/paste will dry out if not used within two (2) years.

15.2.7 Visually inspect, prior to use, all thermite welding consumables, looking for:

a) Imperfections:

i. Cracks;

ii. Nicks or chips; and

iii. Moisture damage or freezing damage.

b) Punctured charge bags:

i. Missing material;

ii. Leaking material;

iii. Signs of rust from moisture; and

iv. Diverter plug is in place and tight.

15.3 Storage of Electric Arc Welding Consumables, Wire, and Electrodes

15.3.1 Protect all electric arc welding consumables, wires, electrodes, and carbons, while awaiting use.

15.3.2 Arrange storage by size and type to allow ease of item selection:

a) Without disturbing other items;

b) Without damaging other items;

c) With a minimum of handling;

d) Do not stack directly on floors, place on pallets;

e) Rotate stock frequently using oldest items first.

Figure 15-4: Palatized Welding Consumables
Courtesy Lincoln Electric, Pinterest

15.3.3 Store all electric arc welding consumables in a dry climate-controlled environment protected from dust, moisture, and freezing:

a) Store and handle all weld rods, wires, and carbons with extreme care. These are fragile and will absorb moisture easily; and

b) Store them in their unopened and undamaged packaging until ready for use.

15.3.4 When transporting thermite consumables:

a) Store in a flat, dry, well-supported area protected from the weather;

b) Keep in original manufacturer packaging or boxes; and

c) Keep from rough handling;

15.3.5 Remove from the wire feed machine any opened or used wire spools;

15.3.6 Store open electrodes in sealed rod sleeves to protect from condensation;

Figure 15-5: Examples of Rod Sleeves
Courtesy ESAB, Hobart, Pinterest

15.3.7 Carry only enough material to support the planned work, with minimal spares.

15.3.8 Dry any welding consumables, that are suspected of being damp or wet, in rod/wire ovens:

a) Refer to the manufacturer's drying instructions that can be found on original container or packaging;

b) Check manufacturer's instructions to determine if the wire or flux-cored wire being used can be redried. If it can be redried, then redry only twice (2 times).

c) Keep open consumables in ovens (these can stay in an oven for several weeks);

d) Open consumables removed from ovens must be used within twelve (12) hours.

Figure 15-6: Examples of Rod/Wire Ovens
Courtesy ESAB, Pinterest

15.3.9 Rotate the inventory stock. All electric arc welding consumables have a defined shelf life as follows:

a) Welding wire, rod, and carbons: two (2) years from manufacture date, if kept in manufacturer's original unopened packaging or containers.

Figure 15-7: Welding Rod
Courtesy Lincoln Electric, Pinterest

15.3.10 Visually inspect prior to use, all electric arc welding consumables, looking for imperfections:

a) Cracks, nicks, or chips in electrode flux coating;

b) Signs of moisture or freezing damage, discolouring, or rust;

c) Flux core wire tubing is not cracked, flattened, leaking material, or rust.

15.3.11 Protect all welding consumables and keep them dry as possible.

15.4 Storage of Welding Gasses and Oxygen

15.4.1 Metrolinx requires that the storage of welding gasses and oxygen, comply with all applicable Federal Canadian Transportation Commission rules and Workplace Hazardous Materials Information System (WHMIS):

15.4.2 **Safety Critical Rule:** Handle all compressed gas cylinders (tanks) with extreme caution:

a) Separate all oxygen and fuel gas cylinders by a minimum of 20 ft (6 m) or by a thirty (30) minute rated firewall;

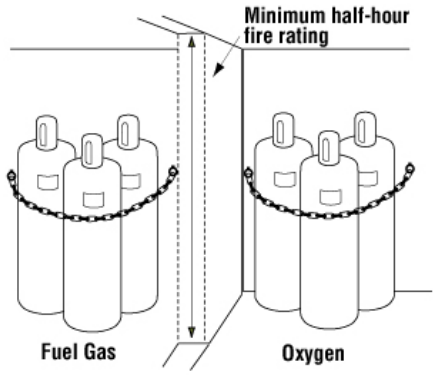


Figure 15-8: Storage of Cylinders
Canadian Centre for Occupational Health and Safety

b) Secure all cylinders/tanks in an upright position;

c) Keep away from excessive heat, any sparks or open flames;

d) Do not smoke near these tanks;

e) Store in a well-ventilated building, container, or shed;

f) Ensure all valve protection caps or safety rings are on and secure. Never remove the valve protection cap until the cylinder is secure and ready for use;

g) Store compressed gas cylinders out in the open if possible;

h) Do not stockpile excessive amounts of compressed welding gasses or oxygen;

i) Mark or tag empty cylinders and separate from full cylinders; and

j) Promptly exchange empty cylinders with distributor.

15.5 Removing Expired Materials

15.5.1 Expired moulds and crucible, weld charge bags, packing sand or mud/paste kits including electric arc welding consumables, must not be left on Metrolinx property. They must be removed from the property and disposed of environmentally or, if possible, returned to the manufacturer for environmental disposal.