TRACK WELDER MANUAL

RC-0506-02TRK-01

August 2018

METROLINX

GO TRACK WELDER MANUAL

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Publication Date: August 2018

PREFACE

This is the first edition of the GO Transit Track Welder Manual RC-506-02TRK-01 August 2018. It is adapted from the CN Track Welder Manual as per the agreement between Metrolinx and CN on March 28, 2013. In accordance with the agreement, Metrolinx is authorized to affix the name Metrolinx/GO Transit to the CN Standards, shall remove all references to CN and update/modify the standards to Metrolinx/GO Transit Standards.

The purpose of the GO Transit Track Welder Manual is to ensure that railway track welder services on Metrolinx and GO Transit owned and operated track are performed utilizing safe, cost effective and efficient methods to meet project or contracted service delivery timelines, and meet on-time operational performance goals. Furthermore, a consistent approach in the application of GO Transit owned track welder methods and standards shall reduce disputes during the design and construction phases of a project, enhance the long term safety, reliability and extend the useful service life of the track infrastructure.

The technical content within the GO Transit Track Welder Manual RC-506-02TRK-01 was modified and developed by the Metrolinx/GO Transit Track Standards Committee members and includes input from railway track welder subject matter experts.

Note

The GO Transit Track Welder Manual RC-506-02TRK-01 document is intended for use by suitably qualified 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 revisions and improvement

Suggestions for revision or improvement can be sent to the Metrolinx/GO Transit Track Standards Committee, Attention: Corridor Maintenance (CM) Senior Manager of Track and Structures who shall introduce the proposed changes to the Metrolinx Track Standards Committee. The CM Senior Manager of Track and Structures 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.

GENERAL REQUIREMENTS

1. The welding standards and practices contained herein shall apply to all tracks and rights-of-way owned or operated by GO Transit ("the Railway"), and UP Express, which are divisions of Metrolinx and are intended as requirements and not intended to replace or supersede the Transport Canada (TC) Track Safety Rules.
2. These Standards do not impose any regulatory requirements.
3. Changes in Railway standards or practices that do not conflict with Transport Canada standards may be implemented on a phased schedule or program, at Metrolinx's discretion.
4. All new or modified materials or equipment shall be subjected to a service test, unless otherwise directed by the Corridor Maintenance (CM), Senior Manager of Track and Structures.
5. All Track welders shall be fully trained in these welding standards and procedures or other Class 1 Railway welding standards and procedures, have a valid Canadian Railway Operating Rules certificate, proof of successful completion of a Class 1 Railway track inspection course, eight years of track construction experience, and a minimum of five years carrying out the role of a Track Welder. They shall hold a valid certificate on thermite welding procedures issued by approved railway manufacturers of the thermite welding product, and shall be re- certified every three (3) years, or at a more frequent period as directed by the CM Senior Manager of Track and Structures.
6. Under the requirements of these Standards, and where appropriate the CM Senior Manager of Track and Structures may delegate his authority to a designated individual.
7. The most current version of the GO Transit Track Welder Manual is located on the MYLINX intranet site at: http://mylinx/sites/RailServ/en/Pages/default.aspx, under title "Track Standards"
8. These railway welding standards and practices are effective as of August 2018.

CORE SAFETY RULES

Rights and Responsibilities

1. We have the right and the responsibility to make decisions based on experience, personal judgment, and training. We must make certain that:
   a. Job tasks are performed only by individuals who are *authorized* and *trained* to perform them.
   b. Job safety briefings are conducted prior to work and when activity and/or conditions change.
   c. Co-workers are informed of *unsafe conditions*.
   d. Unsafe or suspicious conditions are reported immediately to a *supervisor* or appropriate person.
   e. Accidents, incidents, on-duty injuries, and related information are reported to a supervisor as soon as possible; written reports are completed as required.
   f. Practical jokes, horseplay, or physical altercations are prohibited on Company property.
   g. Firearms or any weapons are prohibited on Company property unless *authorized* by the Company.
   h. We comply with all Metrolinx-GO Transit rules and policies that relate to our job task(s).
   i. We comply with all local, provincial, and federal laws and regulations that relate to our job task(s).

Substance Abuse

2. The use of intoxicants or narcotics by employees subject to duty or in their possession while on duty is prohibited. Employees are responsible to know, understand and comply with Metrolinx-GO Transit standards on intoxicants or narcotics.

Clothing and Personal Protective Equipment (PPE)

3. Know, wear, and maintain approved *personal protective equipment (PPE)* and clothing as required by job task and/or *work environment*, including off-site industries as required.

Materials

4. Use approved, properly marked containers when storing or transporting flammable liquids or materials.

Vehicles, Equipment, and Tools

5. Use approved tools, equipment, and materials for the purpose(s) intended. Unauthorized modifications, overrides to *safety devices*, and removal of safety guards are prohibited.
6. Follow instructions and safety information in operator's manual when performing emergency procedures on *motor vehicles*.
7. Inspect all tools, equipment, and related *safety devices* for *unsafe conditions* before use. Remove from service if defective.

8. Do not walk, work, or place any body parts under suspended load.
9. Use *three-point contact* when getting on or off equipment, machinery, or vehicles.
10. Maintain *three-point contact* when ascending or descending steps and ladders.
11. Always use handles provided when opening and closing doors.
12. Shut down motorized equipment when inside buildings not equipped to ventilate exhaust fumes.

Work Environment

13. Protect against *unsafe conditions* in *work area* before and during job activity.
14. Keep *work area and environment* clean, orderly, and free from clutter and debris.
15. Do not litter.
16. Keep emergency exits, fire extinguishers, circuit breaker or fuse panels, and emergency equipment unblocked and readily accessible.

Working On or About Tracks

17. Look for moving equipment when approaching, crossing, or fouling tracks.
18. Expect and keep clear of the movement of trains, engines, cars, or other equipment at any time, on any track, in any direction.
19. Do not step or stand on rail.
20. Do not cross within 25 feet of standing equipment unless you or a member of your crew is in control of the standing equipment.

"Safety Watch - a watch for life"

Goals & Objectives

1. Safety
2. Quality Work
3. Productivity

GO Transit and Contractors' Track Welders are required to, **Safely** produce **Quality** work **Productively,** following all GO Transit welding procedures.

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Chapter 1: Identification of Turnouts & Components

Introduction

A turnout is used to move railway equipment from one track to another.

There are many different types of turnouts and a large variety of component parts. The type of turnout used within Metrolinx Railway Lines depends upon the location, use and speed through which it will be operated and the type of traffic or motive power which is to be operated through it.

This text is intended to present the knowledge needed to correctly identify turnouts and their components.

In general, turnouts are constructed on and supported by either wood turnout ties, concrete turnout ties or steel turnout ties. In some cases a turnout may be built on a concrete slab or a solid steel base. All have their specific applications.

1. Switch
2. Closure (or lead) Rails
3. Frog
4. Toe of Frog
5. Heel of Frog
6. Turnout (or diverging) Track
7. Main Track
8. Track Ties
9. Guard Rails
10. Switch Ties
11. Turnout Lead
12. Point rails of Switch
13. Throw of Switch

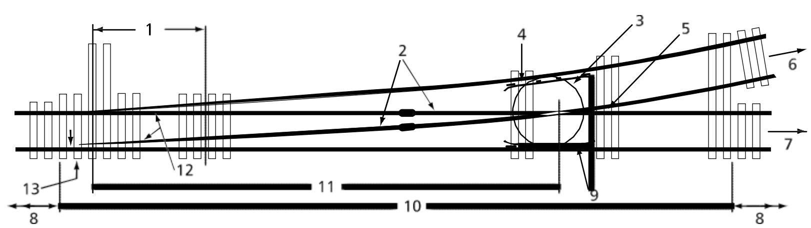


Figure 1.1

1. Turnout identification

Types of turnouts

There are several types of turnouts. **Lateral turnouts** are called right hand turnouts when the track runs off to the right. They are called left hand turnouts when running off to the left. This identification is made when you are standing in the middle of the track at the points and facing the frog.

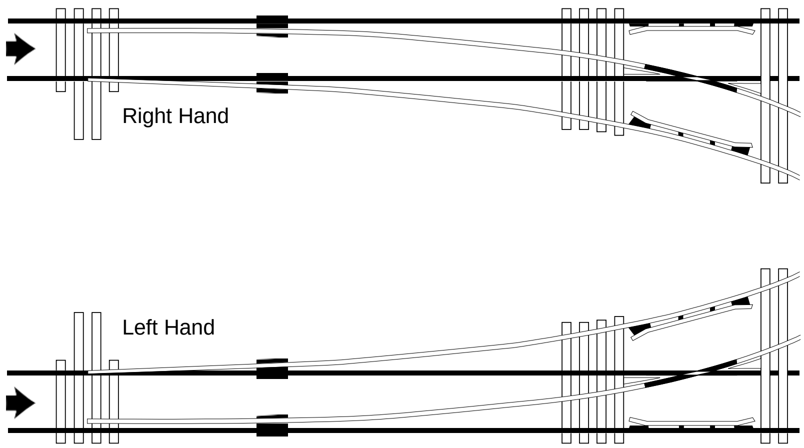


Figure1.2–Lateralturnouts

An equilateral turnout permits higher operation speeds than would be permissible through the turnout side in a lateral turnout. In an equilateral turnout, the frog is placed so that half the curvature is on the main track side, and half on the turnout side. Therefore, the curve angles are smaller allowing the higher speed.

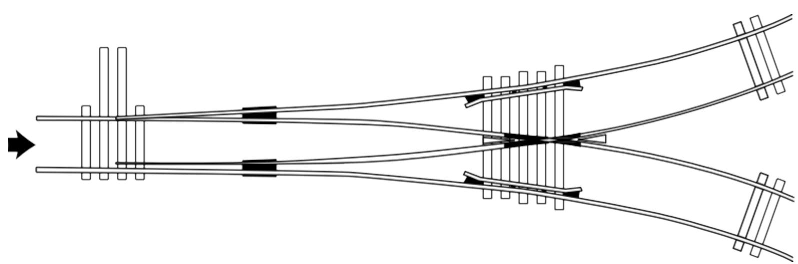


Figure 1.3 –Equilateralturnout

Split Switches are the most common switches used today. Since 1989, 136 lbs. switch points have been made of low alloy deep head hardened rail, and switch points in lighter sections of 300 BHN minimum, intermediate hardness rail; but older points of carbon steel, Hi Si and various alloys also will be encountered.

The ratio of the length of the planed portion of the switch point to the overall switch point length is a function of the turnout geometry and the width of rail head, and is different for each switch point design. (Usually about half its length)

On the top, gauge and field sides the point is planed for about 1/2 its length from 1/8” thickness to full width of head and the point end ground to a sharp edge.

Lap Turnouts have 2 sets of switch points, and three different frogs are used. The reference point is the first set of points. This type of turnout is normally only used in yards and terminal areas to provide greater flexibility of movement, and access to more tracks.

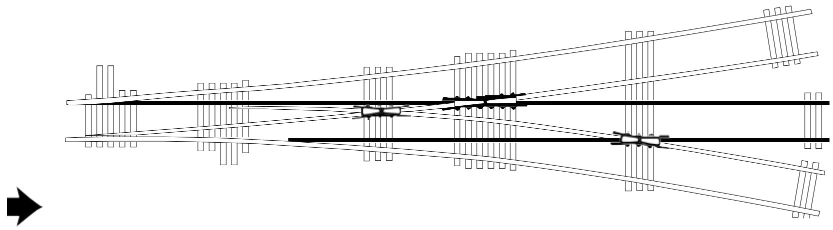


Figure 1.4

Turnout numbers

The frog used determines the number of the turnout. For example: a No. 12 frog in a No. 12 turnout.

At GO Transit we have the No. 8, and the Nos. 9,10,11, 12, 16 and 20.

New designs included “All-welded turnouts” which allowed installation of these turnouts on concrete switch ties.

Weight

Along with the standardization of turnout numbers, the number of rail weights (the weight of a rail is based on how much it weighs in pounds per yard) for any turnout has been limited also. The purpose in limiting the number of turnout types was not intended to eliminate all other plans for other turnouts. All outdated plans, because of inconsistencies in turnout details, are still being retained for information and parts replacements.

New turnouts can only be ordered in 115 lbs. and 136 lbs. rail weights. Replacement components can be obtained in 100 lbs. to 136 lbs. weights.

2. Method of operation –Points

Hand throw type

These types of points are activated by hand, using a manually operated switch stand, and use may be restricted by a foot lock or an electric lock in order to prevent them from being turned until the lock is released. The electric lock is controlled by the Dispatcher.

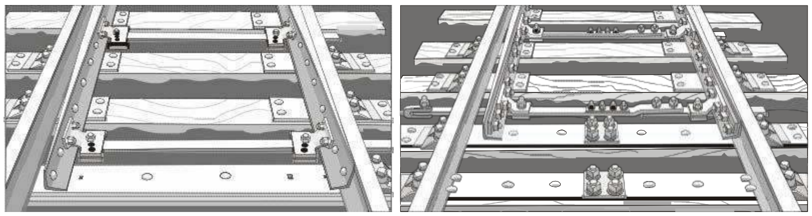


Figure 1.5

A spring switch has the same basic components as a hand throw switch, except that it is equipped with a spring mechanism and oil buffer cylinder attached to the number one (1) switch rod, and the points themselves are reinforced by an additional steel bar along their length.

They are designed to allow “trailing point” moves through the turnout without stopping the train to throw and reset the points. The points are held in the normal main-line position by heavy springs in a cylinder which form a part of the connecting rod assembly between the operating lever of the switch stand and the switch rod.

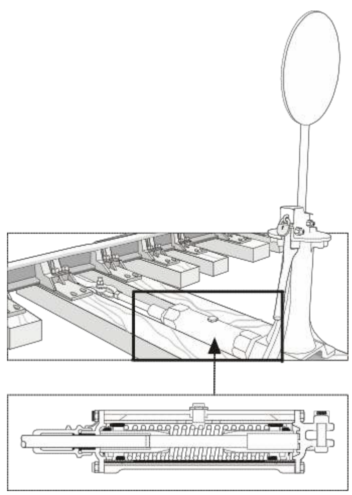


Figure 1.6

An oil cylinder and plunger prevents the points from returning too fast to the normal position. A properly adjusted switch should return in 10 to 12 seconds.

Power switches

A power switch, in general, looks like the hand operated type but is equipped with an electrically operated power machine. The closed switch point, in the normal position, is held against the stock rail by the force exerted through the operating rods and the switch machine.

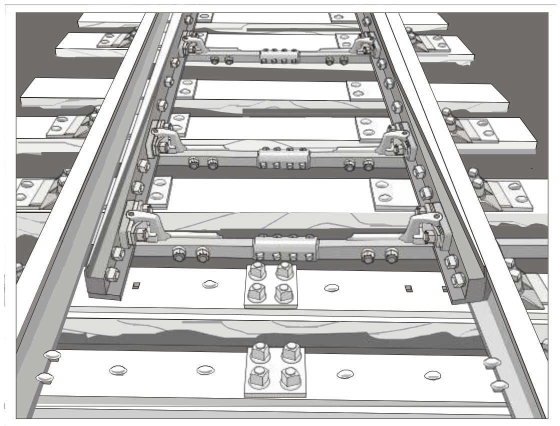


Figure 1.7

Dual control

A dual control switch is a power operated switch which can be operated either manually by means of a hand throw lever located at the switch or by remote control from the Dispatcher.

Semi-Automatic

In semi-automatic operation, the hand throw switch can be trailed through from either track but must be lined by hand for a facing point movement. It can only be used in yards. It cannot be used in winter when snow or ice may affect the ability of the switch points to close properly.

3. Standard plans forturnouts

All parts of the turnouts are clearly shown on these plans.

Each weight and type of turnout is covered by a plan. These plans are called GO Transit Track Standard Plans" or GTS Plans. They show design details, materials, frogs, switches, guard rails and special components.

Specifications, data and bill of materials are shown on standard plans. Each plan has a basic number followed by letters to indicate whether the turnout is right or left hand and the position of the point operating stand or machine.

When referring to a specific turnout, state the correct drawing number and corresponding letter to indicate whether it is left hand or right hand detail that is required. See GTS-0 for explanation of letter codes.

4. Turnout components

To properly identify the proper type and quantity of individual turnout parts required for a specific turnout, it is necessary to refer to the proper plans.

Types of switch points

a) **Manganese Steel** or points are used in turnouts in paved streets.

b) **Carbon Steel**

Up to 1986, Carbon Steel or Hi Si rail was used in manufacture of switch points 132 lbs. and lighter. Since that time, Standard Hardness rail (300 Brinell minimum) has been used.

c) **Samson Type** points are utilized in spring and power switches, long or curved switch layouts, very heavy duty and high speed applications. A Samson type switch point **must not be installed with a standard stock rail.** The design is such that the stock rail must be undercut to accommodate the point. Under normal conditions a Samson point is installed on the mainline (tangent) side of a turnout. However, two Samson points may be required when the switch is installed on long curved switches, or at equilateral turnouts. All 136 lbs. turnouts require two (2) Samson switch points and will therefore require two (2) undercut stock rails.

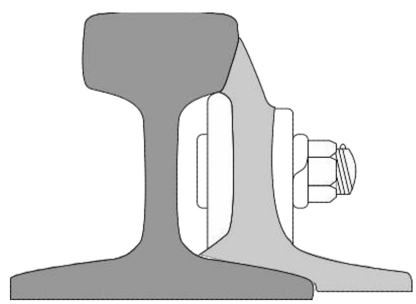


Figure 1.8 - Samsonpoint

Replaceable Point Inset manganese steel tips are used for applications where traffic is heavy.

Reinforced points have 1-1/4" reinforcing bars installed on the gauge side in addition to the normal reinforcing, for added support and protection against point failure at spring switches.

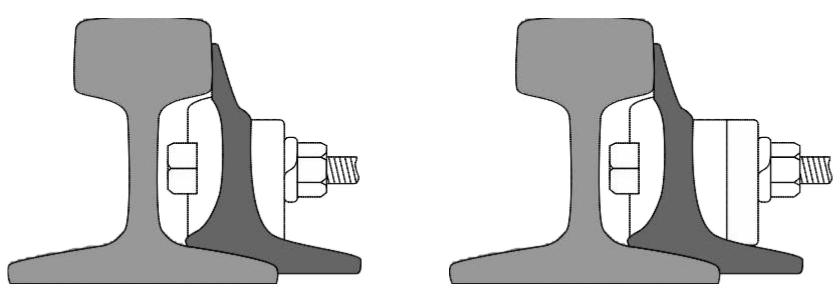


Figure 1.9

Left and Right Hand Points are identified in the same manner as for a turnout that is “FACING THE POINT OFSWITCH”.

The Length of a switch point required for a particular turnout is determined by the number of the turnout or the angle of the frog, and the type of turnout.

Stop Blocks are preinstalled on the web of the switch point to hold the point in the correct alignment and keep it from moving outwards when traffic is running on it.

Switch point lock

This is a device that holds the switch point to the stock rail to prevent its opening under the passage of facing point traffic, or in the event of an accident, where the switch stand is demolished.

A Switch Point lock is installed on a switch point whenever there is a public crossing 200’ or less from the switch, in a facing point direction. Before operating the points, the retaining hook must be removed and the lock released by depressing the foot pedal. Switches having this type of lock should have the top casting painted white.

Generally it is installed at switches having a facing point installation within 200’ of a road crossing at grade ().

Near point type

The near point type is only to be applied to GO Transit approved Rigid Type switch stands. The Make of point lock required and weight of rail on which it will be applied are factors which must be known in order to accurately requisition this item. Ordering details consult Corridor Maintenance SeniorManager of Track and Structures.

Note:

With this type, no connecting rod is required and when used with Samson Point switches the bolt head must be ground.

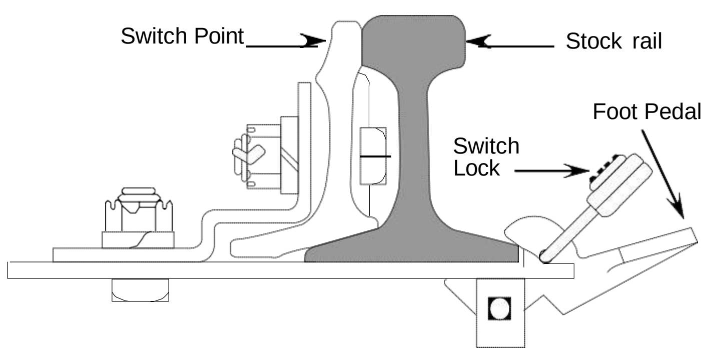


Figure 1.10-- Switch pointlock- nearpointtype

Far point type or special far switch point lock has a longer rod with a special end for attachment to the far point. They may be insulated for use with electrically locked switches. The Corridor Maintenance Senior Manager of Track and Structures will direct the use of this type, which is treated as a special item.

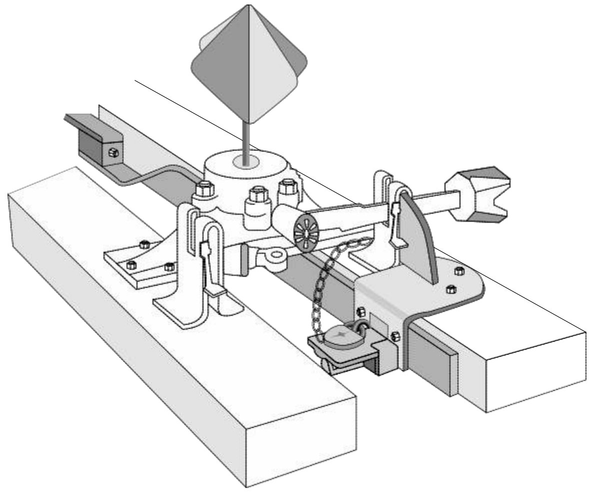


Figure1.11-Switch pointlock-far pointtype

Stock rail

The stock rails may be, Hi Silicon, Alloy, or heat treated steel. They must be of the same rail weight and about the same hardness as the switch points to get the best wear.

All switch points used on Metrolinx-GO Transit Railway Lines have some entry angle at the tip. To accommodate the entry angle, a horizontal bend must be made in the diverging side stock rail on lateral turnouts, and in both stock rails of equilateral turnouts.

All turnouts other than all-welded turnouts are designed for the possibility that non-Samson points may be used; so the bend in the stock rail is set some distance ahead of the tip of point so the gauge will not be tight at the tip of points. In all-welded turnouts, which use Samson points exclusively, the bend in the stock rail should go opposite the tip of the points.

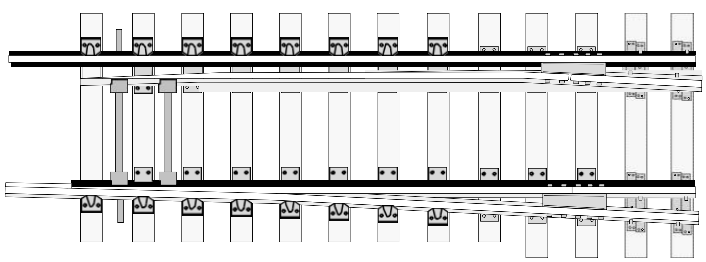


Figure 1.12

The point is protected from direct impact of the wheel because of the bend in the stock rail, the beveling and the sharp edge of the point.

Heel block assembly

The heel block keeps the correct distance between gauge side of stock rail and gauge side of the points, at the heel of the switch.

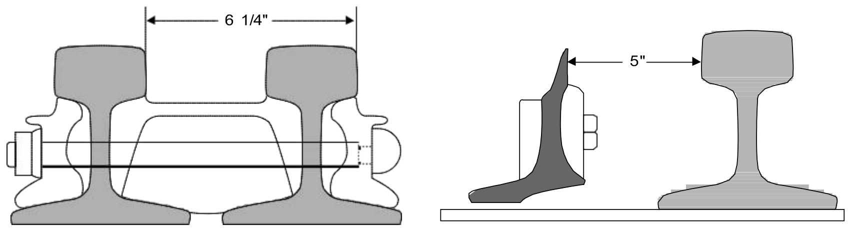


Figure 1.13

Strength and rigidity is given by inserting steel heel blocks between the joint and the stock rail. For 132 lbs. and lighter, the point is coupled to the adjoining rail by a special bent splice bar, pipe thimble, and heel block bolts allowing the point to pivot at the heel. Ensure that all heel casting bolts are tight. The heel spread is usually taken as 6-1/4" and is balanced to give correct flange-way. The assembly used on some 136 lbs. turnout is not bolted through the two rails. The assembly used on all-welded turnouts, which essentially is a floating heel block.

Switch point guard

A switch Point Guard fits on the long gauge plates of the turnout just ahead of the tips of switch points, and works in the same way as the raised guard of a self-guarded frog, off the outside of the wheel rim. At one time switch point guards were made of solid manganese castings, but all such guards are now made of heavy steel weldments, with a separate wear bar that can be adjusted inward as it wears.

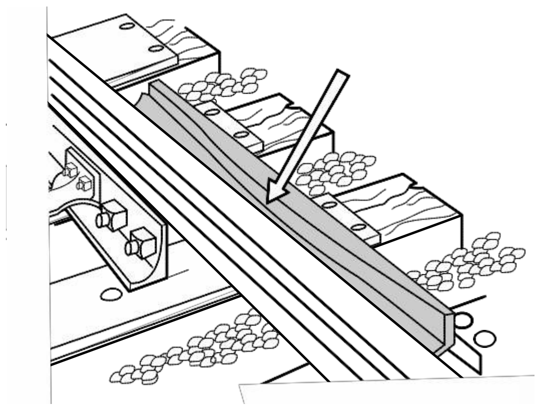


Figure 1.19

Switch point guards last longer than switch point protectors in heavy service because their bearing surfaces are much larger. They are also not vulnerable to breakage if the gauge face of the stock rail ahead of the points becomes curve worn, a problem with bolt-on type protectors.

Switch rods

Switch rods hold the switch points together at a designated distance. They extend longitudinally in close proximity to the base underside of the stock rails and serve to hold the points down.
The number of switch rods used depends upon the length of the switch point and their method of operation. The number of rods varies from 1 to 4, and in some cases more. They are evenly spaced from the point to a distance of 1/2 to 2/3 of the point length.

The front rod extends under the stock rails to provide a connection for the connecting rod from the switch stand or machine to the switch point clips. Many existing turnouts were constructed with old style rods.

Description of switchrods

Horizontal and Flat switch rods are rectangular shaped bars of sizes proportionate to the rail weight and made to be used with side jaw switch clips.

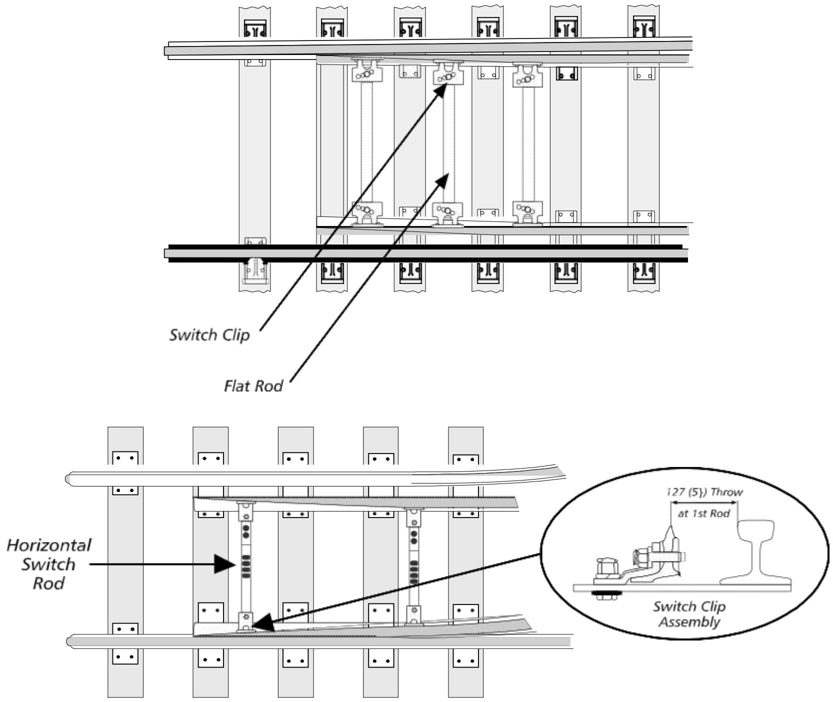


Figure 1.20

Vertical switch rods provide positive engagement of the rod to the "MJ" (Movable Jaw) clips. A fine adjustment permits accurate setting of the switch throw. A "MJS" clip eliminates the distinction between right-hand and left-hand clips, and will also eliminate the need to shim the clip to keep them from binding.

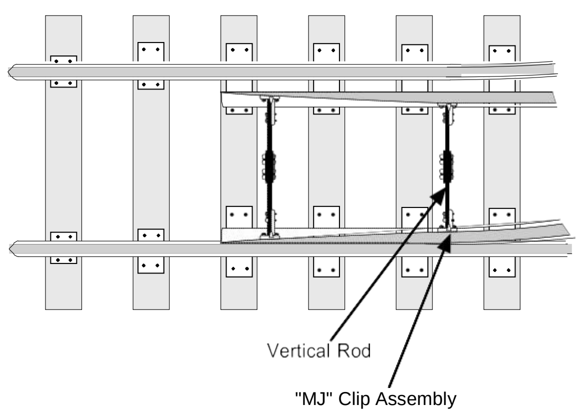


Figure 1.21

Switch Clip is the device that attaches the switch rod to the switch point. Horizontal switch clips allow the switch rod to lie with its broad side horizontally. Vertical switch clips position the broad side vertically. Both types allow rotation of the points with reference to the clips.

The difference between the old and the modern type switch rod, is that the old style rods are one piece and the switch point adjustments are made by moving the bolts in the proper hole of the switch clip.

The modern rods are two (2) pieces and adjustments are made by moving the saw tooth joints at the center of track, and bolts tightened to the proper switch setting.

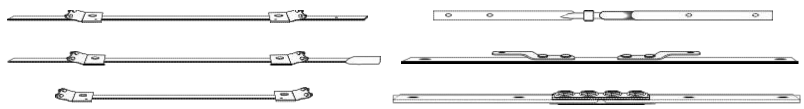


Figure 1.22- Old style switch rods

With the standardization of Turnouts, newly developed models are now in use. All newly developed switch rods conform to latest revisions of Metrolinx-GO Transit Special Track-work Specification document.

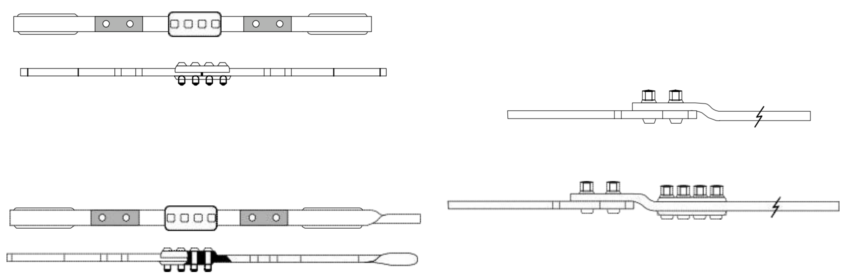


Figure 1.23- Modern switch rods

They are suitable for standard gauge track with 100, 115, 132 and 136 lbs. rails. .

Connecting rods

Commonly called operating or throw rods, they are attached by an adjustable connection to the crank eye bolt of the switch stand or throw mechanism of the power machine, and to the front switch rod. Types vary to suit the application.

For parallel throw switch stands, the spring connecting rod may be furnished when specified. The type may vary to suit the switch stand and the length may differ to allow mounting of the stand farther from the centerline of the track to facilitate the view by approaching trains.

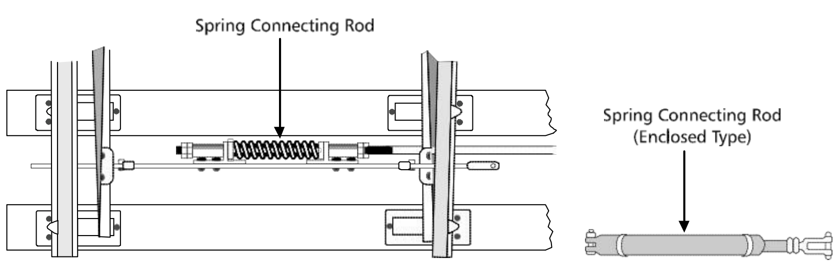


Figure 1.24

Note:

A spring connecting rod must **not** be used in connection with a Pettibone mechanical switchman in main track service, as it would prevent the mechanical switchman from working properly. Such devices are meant for use only in light duty yard service.

Turnout plates

Each type of turnout has a specific set of plates. Plates differ in shape and quantities for each turnout number or size. Gauge plates are placed under the toe end and ahead of the point of switch. They are channeled, to hold the rails to the proper gauge, and extend beyond the stock rails to fit rail braces on each end. On 100 lbs. and heavier turnouts installed before about 1971, a bent gauge plate was used under the switch points.

On recently installed turnouts 100 lbs. and heavier, the gauge plate is **not bent**. The angle of the bent stock rail is accommodated by angling the channel in the plate to match the stock rail angle on the turnout side of the gauge plate.

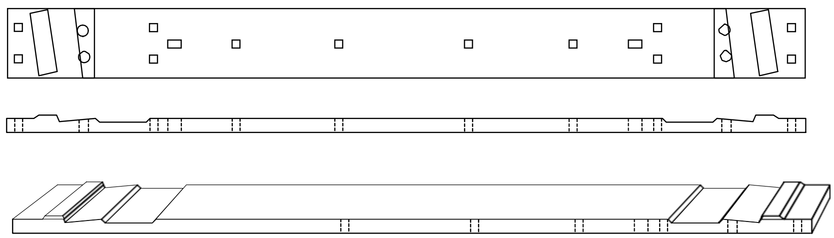


Figure 1.25- Typical, non-insulated gauge plate

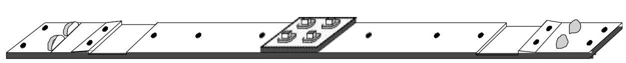
The plate number and GTS number including the sub-letter (as GTS-207D) must be indicated. In addition to the gauge plates, switch points are designed to carry the point rail 1/4" above the level of the stock rail, to lift the false flanges of wheels over the top of the stock rail in trailing movements and keep the false flanges from rolling the stock rail over.

Switch points and plates come in two basic designs. In the uniform riser plate design the point is level, 1/4" above the stock rail, for its full length, and the difference in level is run out in the closure rails behind the heel block. On Metrolinx-GO Transit all turnouts except 132 lbs. are uniform riser plate type.

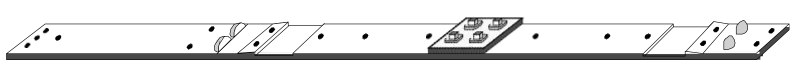
In the graduated riser plate design, used on only 132 lbs. turnouts, the point has two vertical bends, and the plates toward the heel are matched to different depths to gradually lower the point back to level at the heel.

The insulated gauge plates used for **manual** and **spring operated** turnouts are constructed in two sections or halves bolted together at their ends, through fibers and bushings. The insulated gauge plates for **power operated** turnouts are also in two sections or halves and are longer on one side to permit machine mounting.

On spring and power operated turnouts, additional gauge plates are used to provide rigidity. They must be differentiated between left and right by use of plate number.



Manual and spring operated type



Power operated type

Figure 1.26 – Insulatedgaugeplates

On turnouts having uniform riser plates, the **turnout plates** are laid behind the heel block to run out elevation between the points and the stock rail. Between the heel end of the switch point and at and past the frog, special numbered plates, hook twin tie plates, multi-tie frog base plates, and ordinary tie plates are used.

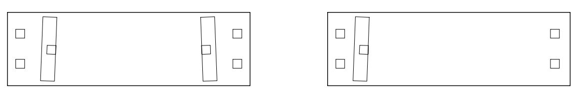
At supported insulated joints (other than continuous joints) where wood ties are used, rubber tie plates must be used under the joint. Where Pandrol plates are used, as in 136 lbs. turnouts, special tie plates are also required at suspended joints if bonded insulated joints are used, to prevent shorting the signal circuits.

Note:

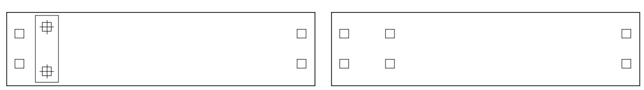
GTS plans for 115 lbs. all welded turnouts feature “rolled” double shoulder plates, instead of hook-twin tie plates. Hook-twin tie plates have been completely eliminated from these turnouts.

GTS plans for all 136 lbs. and 115 lbs. turnouts have eliminated use of hook twin plates completely, using large flat plates at heel of switch and under frogs and guard rails. The 132 lbs. turnouts also have eliminated hook twins for frogs and guard rails, but have had to retain them behind the heel of points because of the graduated riser plate design.

Turnouts in weights 132 lbs. and lighter use standard track spikes to secure the track material to the ties. All 136 lbs. turnouts are supplied with elastic clips and require special plates secured to the ties by screws. Generally, either 19mm (3/4”) lag screws can be used or, the screw size will be increased to 24mm for greater strength and stiffness.



Toe End - Spring Frog Plates



Heel End - Spring Frog Plates

Figure 1.27

Rail braces

Rail Braces are secured to the gauge and riser plates already described, and as the name implies their purpose is to brace the stock rail and guard the rail against lateral impact. They also help maintain proper gauge and prevent overturning of the rails.

They bear against the outside base and under the head of the stock rail to resist the lateral thrust on the point and stock rails.

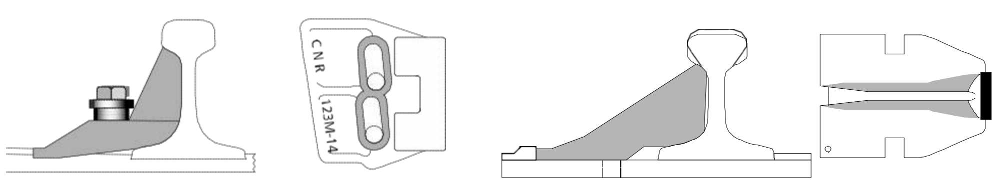
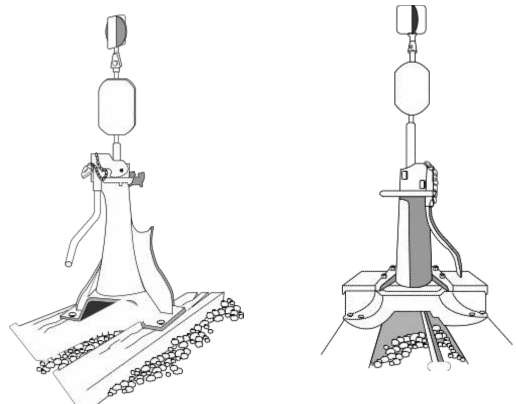


Figure 1.28

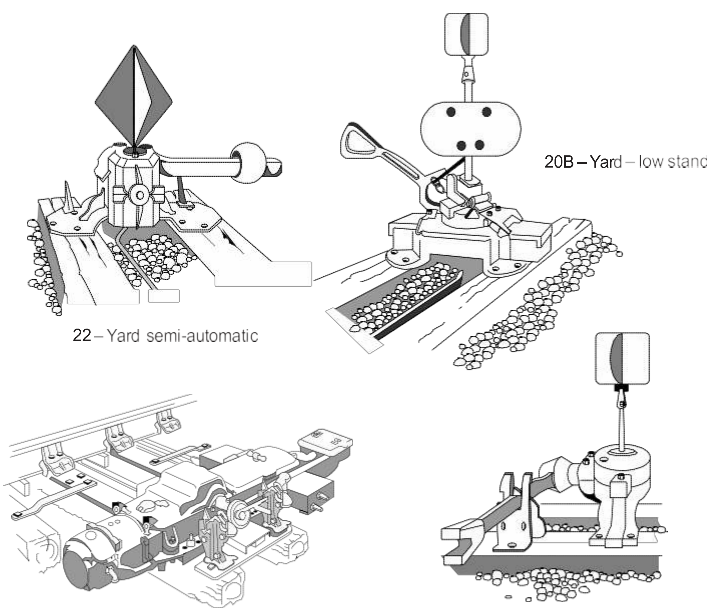
Switch stands

Switch Stands used on Metrolinx-GO Transit are as follows:



31B–Standard-maintrack 17B– Standard- yardtrack

Figure 1.29



22 – Yard semi-automatic

Maintrack – power switch 36D - Maintrack, siding and yard tracks

Figure 1.30

Switch stand tip assembly

Mounted on the switch stand tip are switch lamps or reflectorized target tip assemblies to make them visible at night.

The target plate must indicate the colors normally shown by the target tips when the turnout is set for the curved route.

Frogs

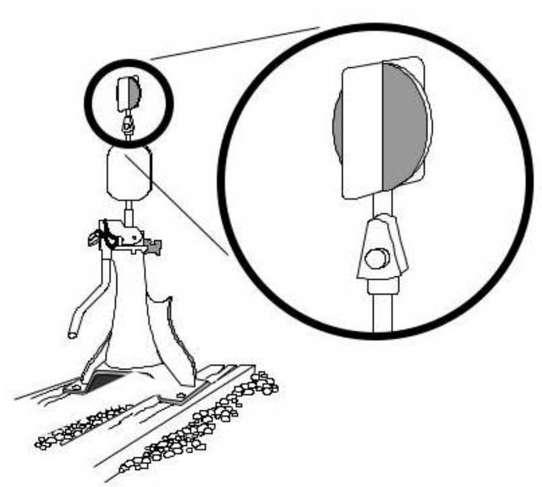


Figure 1.31

Since a turnout is known by the frog number, its **identification** is of prime importance.

It would not be practical to try to put a razor point on a frog, as the point would not be strong and would break off under traffic. For strength, the point is made blunt, about 1/2" wide at the gauge line at the tip. This blunt point where the gauge lines are 1/2" apart is called the 1/2" point.

The number of a frog can be found in the following two methods.

First method:

- Measure from the true point of frog to the heel of frog.
- Next measure the heel spread from gauge side to gaugeside.

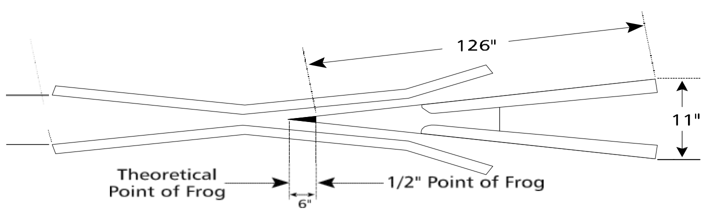


Figure 1.32

- Divide this distance into the length found from the true point to the heel. This gives the frog number. For example: True point to heel: 126" + 6" = 132"

Spread at heel = 11

Frog number: 132 ÷ 11 = 12 therefore a No. 12 Frog.

The second methodis:

AREMA defines the frog number as “the number of units of center line length in which the spread is one unit”. To determine the frog number, mark the point on the heel where the distance between the gauge lines is one inch. Mark the point where the distance between gauge lines is six inches. The difference is five inches. If the distance between the two marks is 40 inches, the frog is a No. 8; 60 inches, a No. 12; 100 inches, a No. 20.

Bolted Rigid Frogs are made of rail sections bolted together.

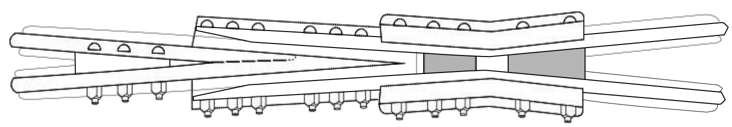


Figure 1.33

Heel blocks and rolled steel filler blocks separate the rails and provideflange-ways.

Spring Frogs hinge the movable wing rail on the turnout side. That wing rail is reinforced similar to the switch points. The movable wing is held in line with the running rail by springs (contained in a cylindrical case) to provide a solid support and a continuous surface.

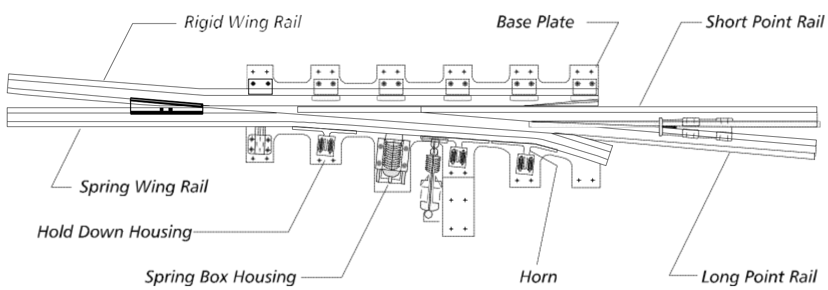


Figure 1.34

When moving through a spring frog, the wheel flange pushes the wing outward against the spring to provide an open flange--way. The flange-way is closed by the spring after the passage of each wheel. Hold down horns sliding into hold-down housings welded to the base plate restricts the wing from moving up and down.

Spring frogs must not be installed without an anchor block. Only spring frogs are defined as right or left hand.

Rail Bound Manganese Steel Frogs have a replaceable manganese steel insert secured within rail sections.

Special types of glued RBM frogs with long legs are available for use with all-welded turnouts.

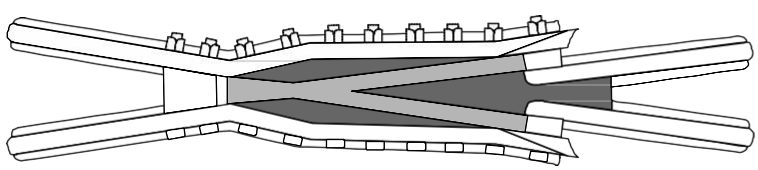


Figure 1.35

Self-Guarded Manganese Steel Frogs are provided with integral flange guards, therefore do not require separate guard rails. Point protection is provided by vertical risers forcing the wheels away from the point. This type of frog must not be installed in the main line, or any track where speed will exceed 15 mph.

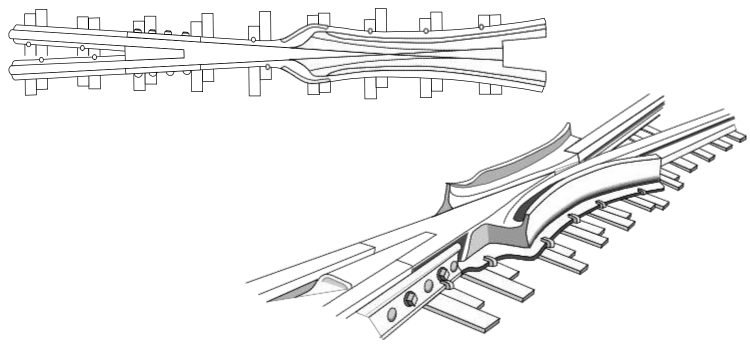


Figure 1.36

Note:

In addition to these 4 basic types of frogs, other types exist.

Some samples are solid manganese frogs, and various types of power operated frogs such as movable point diamond frogs and swing-nose and swing-wing frogs.

The Frog Protection Rail must be of the same length as the frog and may be used as a temporary replacement should the frog become defective and no replacement frog is immediately available. When present, it is usually coupled to the heel of the frog on the turnout side and extends into the siding.

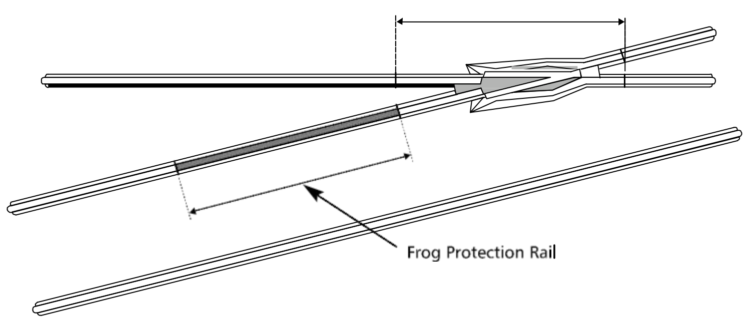


Figure 1.37

If frog protection rails are used to replace the frog, it is important to:

- Notify the Rail Traffic Controller and the Rail Corridors Manager of Track that the turnout is out of service.
- Spike the switch points in the normal position so a train cannot mistakenly derail where the rail is removed.
- Replace the frog protection rail with another frog of the same type and number as quickly as possible and advise the Rail Traffic Controller.

Guard rails

Guard rails are important turnout components. They are off-set opposite the frog point to keep the wheel flanges from striking the point. Left and right hand end castings are located near the ends of the guard rail.

For 132 lbs. and lighter turnouts in particular:

The adjustable separator block is secured with bolts through both the blocks and the rails. Other guard rail types are made in one piece with braces and plates. Guard rails can be obtained in different weights and lengths and both must be specified.

Note:

The 136 lbs. guard rails use spacer blocks bolted to the guard rail and held in position by special plates and adjustable rail braces. For example, for frog numbers 16 and 20, the length is 16'6" and for frog numbers 8, 10 and 12, the length is 11', except for the 136 lbs. turnouts, where guard rail lengths vary according to plan. (Refer to GTS Plan 1123 for current lengths.)

Switch or turnout ties

Switch ties, or turnout ties are necessary to support the turnout. The ties increase in 1/2 foot lengths from 9' to 16' as the size and spread of the turnout requires. Under the switch points, the first two 16' switch ties known as head blocks, act as a base for the ground throw lever and the switch stand. A power switch operating machine is mounted on two 12' to 14' ties.

Remember that switch ties are specified in sets by frog or turnout number for each designated number of turnout. See bill of material on reverse side of turnout drawing for exact lengths and quantities.

Turnout Improvements

During the early 1980's the CN Engineering Department was asked to review its design of existing turnouts to meet the needs of higher axle loading of 100-ton cars, coupled with increasing volumes of traffic, particularly unit trains resulting in excessive wear and maintenance costs to track components.

The fully pandrolized 136 lbs. (jointed rail) turnout was introduced. This turnout was fastened with pandrols, and lag screwed to hardwood switch ties.

Next, after completion of the fully pandrolized turnout, the all-welded fully pandrolized turnout on concrete ties was introduced. It was a No. 20, 136 lbs. turnout and was installed in mainline, during 1984.

The huge turnout was assembled in a turnout assembly plant and shipped to the installation site. Considering that the longest tie weighs about 1300 lbs. and that a No. 20, 136 lbs. turnout is about 230 feet long, a total turnout weighs about 100 tons. The 1984 test turnout was lifted into position using hydraulic jacks. Forty (40) ton cranes can also be used to lift panelized portions into track, as was done at a subsequent installation in 1986. Such a method requires more heavy machinery and needs more welds to close up.

Two sets of concrete switch ties were supplied to CN by "CXT", a Canadian (now American) based company. A Swedish company has supplied (under test) one set of cross-over switch ties. The main difference in design of switch ties by each, is that the Canadian tie lengths increase in increments (similar to wood switch sets) along the diverging route, while the Swedish version increase gradually along the diverging route, resulting in a neater appearance.

Several major differences stand out between our all welded pandrolized turnouts and our conventional models. The conventional turnout consists of standard (carbon) jointed rail. Since 1986, 300 BHN minimum Intermediate Hardness rail has been purchased instead of carbon steel for use in turnouts. Hardwood ties for main line; hardwood or softwood elsewhere, fastened with track spikes. The pandrolized all welded turnout uses premium rail, is fully pandrolized with hardwood or concrete switch ties, with glued frog and featuring revised geometry with a continuous curve from the point of switch through to about the toe of frog.

The following are some examples of various turnout options available.

TURNOUT CONFIGURATION	Number	Remarks
Jointed turnout Curved Points	20	Wood ties, spikes, carbon rail, soft hardwood ties, hook twin plates. Rail weight 132 lbs. and less.
Jointed Turnout Straight Points	8, 10, 12 & 16	Same as above.
Pandrolized Turnout Curved Points	16 & 20	Wood ties, pandrols, frog gauge plates, long guardrails, lag screws, Samson points (both sides) 136 lbs.rail.
Pandrolized Turnout Straight Points	8, 10 & 12	Same as above.
All Welded Turnout Continuous Curve	10 & 12	Wood ties, premium rail, spikes, frog gauge plates, Samson points (both sides), regular guard rails 115lbs. rail.
All Welded Turnout Continuous Curve	10, 12, 16 & 20	Wood ties, as per jointed c/w one continuous radius, 136 lbs. rail.
All Welded Turnout Continuous Curve	20	Concrete ties, same as above, plus “EVA” tie pads.

Technical references

GO Transit Track Worker Safety Instructions

GO Transit Track Standard Document

GO Transit Track Standard Plans,

Chapter 2: Welder's Track Inspection & Pre-welding Maintenance

General inspection

Although the regular duty of inspection is assigned to the Track Maintenance Foreman or Person responsible for inspection patrol, it is also the duty of Track Welders to inspect track in the general area in which they are working in accordance with the GO Transit Track Standards document. This means that Welders must be able recognize the condition of track, turnouts and diamond crossings and take action to correct a problem, and insure the integrity of the structure for the safe movement of Rail Traffic. Do the work, if it pertains to welding or grinding requirements, or report the defect to those responsible for that territory As Soon As Possible.

Welding, Track and Signal and Communications work forces must cooperate and advise each other of defects, improper adjustments, or work to be done which are the responsibilities of each group. Some of the conditions you should watch for include:

Item	Condition
rail	broken, discolored running surface, damaged
splice bars	cracked or broken
bolts and washers	broken, loose, or missing
tie plates	missing or broken
spikes	high or missing
anchors	missing, not properly against tie or damaged
ties	damaged
ballast	voids (hole ordepressions)
line	misalignment
surface/cross level	uneven track or surface
drainage	high water or blocked culverts
roadbed	abnormal depressions, cracks or slides on the embankments
clearances	obstructions closer than 183 cm (6ft.) from the gauge side of the rail
road crossings	loose, missing, or high planks, high spikes, obstructed flangeway, or holes in the crossing surface

When track or any track component is found to be in such condition to render it unsafe for traffic at normal speed, one or more of the following must be done and they are listed in no particular order of importance and some items are linked together:

a) Determine the cause of the defect.

b) Repair the defect.

c) Record and report conditions to those responsible.

d) If needed, advise the Rail Traffic Controller.

e) Reduce traffic speed if required, suitable to the condition.

f) Halt all operations if necessary.

Inspection is necessary to determine the need for preventive maintenance, which in turnreduces major maintenance costs, minimizes train delays and eliminates hazardous conditions.

Track maintenance before welding

When track welding is found to be necessary, more often than not, it's an indication that either track maintenance or **preventive** grinding has been lacking for sometime.

Welding and/or grinding should never commence until all other maintenance conditions requiring attention have been dealt with, e.g. a rail-end weldment on a poorly surfaced joint is certain to fail within a short period of time. At times it becomes too late to repair by welding and costly replacement of the defective component is necessary.

It is not the regular duty of Track Welders to replace cracked or broken splice bars or defective ties; if these are found to be in need of replacement, the track must be protected if necessary and track group notified.

Materials and tools

The Track Welders should have these tools readily available and a small supply of these materials on hand.

Tools	Supplies
track jack	spikes/compatible fasteners
lining bar	bolts
tamping bar	washers
claw bar	tie plugs
spike hammer	tie plates
track wrenches various sizes	
sledgehammer	

Rails-end joints

The rail joint assembly must be complete and secure. Broken splice bars, bolts, washers, tie plates or missing spikes must be replaced. The joint must then be properly surfaced. When track forces are not available to perform the tasks refer to GO Transit Track Standards document and accomplish the task to do.

1. Tighten all bolts to standard torque. Proper torque or tension is required to hold the joint firmly in place. Over tightening will stretch the bolt and weaken it. Use a standard track wrench, with no extension handle, to tighten track bolts. The length of the wrench is designed to provide adequate torque. Tap the top edge of the splice bars lightly with a sledgehammer to seat the bars when tightening but do not tap the bolt heads. Bolts must be tightened in an alternate sequence starting with the two center ones first, and the two outer at each end last.
2. If the tie plate is to be repositioned or replaced due to bends, breaks or corrosion, be certain it is centered on the tie and the outside shoulder provides full bearing against the outside base of the rail. Be certain it is of the proper type, and conforming to the other tie plates on neighboring ties.

3. If spikes have worked loose, per GO Transit Track Standards section 9.4, tie plugs must be inserted before re-spiking with straight, unworn spikes, and vertically driven to provide a full bearing against the edge of the base of rail. Spikes must not be driven to contact the top of the base of rail.
4. To surface the joint:
   a) Sight along the rail head to determine the height required to bring the joint level with the rest of the rail.
   b) Place the track jack on field side and lift the rail to level.
   c) While one person holds the tie up in position with the lining bar, the other packs ballast beneath at least three ties at the joint.
   d) Release the jack and sight the rail head again to check surfacelevel.
5. Weld and grind as required.

When rail-end batter on an insulated joint is to be repaired by welding, track forces must be present to remove and replace fiber bars with standard steel splice bars.

Switches

The switch points are the weakest part of a turnout and regular inspection and maintenance of them are a primary concern. There must be no sharp kinks, loose bolts or rivets. The point rail should fit snugly against the stock rail for at least half of the planed portion. A wheel flange splitting a switch due to an exposed switch point tip is a hazardous possibility.

1. The running surface of a switch point at "the separation of heads" must be at least 5mm (3/16") above the stock rail (Figure 2-1) and the tip of the switch point must not be less than 13mm (1/2") below the top of the stock rail. A new stock rail installed adjacent to a worn switch point can cause a derailment (Figure2-2).

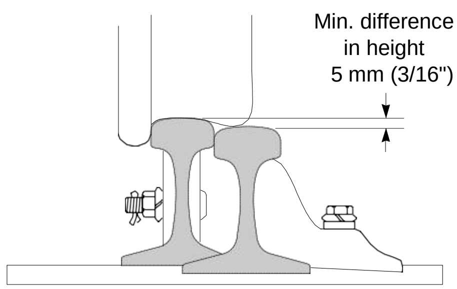


Figure 2.1

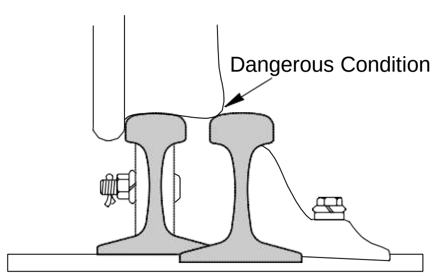


Figure 2.2

3. Rails must not be canted by badly adjusted rail braces.
4. Metal flow must not exceed 1.5mm (1/16”) on the switch point or gauge side of the stock rail.
5. Inspect switch point end for lateral wear and flaws.
6. If welding or grinding of a switch alters the switch adjustment, Track and/or Signal forces should be present to make preparatory or final adjustments where necessary.
7. Carry out the necessary repairs.

Frogs and diamond crossings

In the turnout area, after the switch, the frog is the second in rank of importance for inspection. Conditions to watch for include:

1. Pieces broken out of the running surface.
2. Cracks that lead to breakage (note: vertical cracks in manganese heel, to be monitored and all bolts must be kept tight). Ties tamped up in heel extension area.
3. Excessive wear of point and wing, 10mm (3/8”) maximum.
4. Wear on raised guard (self-guard frogs) 6mm (1/4”)maximum.
5. Lipping or flowed metal on gauge corners.
6. Defects in any casting (see note at#2).
7. Missing or loose bolts and broken washers.
8. Broken or cracked base stops, braces, horns and hold-down housings on spring frogs and diamonds.
9. Gauge and line of the diamond or frog (this usually involves the secure fit of base stops and base plates).
10. Adequate support by ties and ballast.
11. Proper line on through track.
12. Spring wing rail fits tight against point rail (wing of 115 lbs., 132 lbs. and 136 lbs. spring frogs is designed to be open 10mm (3/8”) at the half inch point).
13. Clearance horn and hold-down housing must not exceed 6mm (1/4”) top and bottom. The minimum is 1/8 and 1/4” top and bottom.
14. Spring wing must lay flat on base plates.

Identify

There are several different types of alloy and heat-treated rails and track components across the GO Transit System. Maintenance welding to all of these steels may be carried out provided positive identification is made and proper welding procedure is followed for each particular type.

A tag is often but not always attached to the component or a portion of the rail, indicating the rolling mill and alloy (main alloying elements). However, if the tag has been accidentally destroyed or is missing, branding and/or stamping can identify the type.

Note:

The following photos are examples of tags and are provided for training purpose only. For accuracy, consult the latest GO Transit Track Standard document and GTS Plans.

Figure2.3FrogIDtags

Prepare

Ensure a proper and sturdy foundation of track before welding. Protection against traffic must be acquired when necessary. All cracks and defective metal must be removed prior to welding any track component. The assumption that welding over hairline cracks will eliminate them is false. The weld area must be free of grease and other foreign materials.

Weld

Prescribed preheat and post-heat temperatures and cooling rates must be adhered to in all cases. Recommended welding technique and procedure must be followed. The correct welding rod or electrode is used to ensure a compatible bond.

Finish

After grinding to specifications using a straightedge or gauge as required, all waste material must be swept clear of switch plates, flange-ways, etc. Environmentally approved lubricant should then be brushed lightly over the weld area before total cool out to prevent rust. Bolts also should be lightly oiled.

Chapter 3: Care and Use of Hand Tools

Introduction

Practice in care and use of hand tools results in greater safety. Good quality work is reflected in the proper care and use of hand tools. If the tool car or storage area is tidy, with tools all in good working order and well laid-out, it is usually the case that the employees responsible for this equipment are efficient in other areas of their work as well. Disorder in GO Transit or Contractor supplied boarding accommodations, vehicles, and tool cars are likely signs of careless work on the job site. Small tools not placed in proper bins or racks and ladders not properly positioned and secured, are examples of hazards that could cause an accident.

Efficiency

Neat and tidy surroundings generally result in minimum waste of time and material. A foreman who maintains facilities and equipment in a neat and tidy condition has fewer crew injuries on the job and helps maintain productivity to a maximum. If everything is where it belongs, the time spent looking for tools and material will be reduced to a minimum, as well as helping to prevent the loss of tools and material.

Employee’s responsibility

All Contractor or GO Transit supplied welding equipment, from electric-arc welding machines to chipping hammers are of industrial quality, built to withstand the rigors of daily use. However, if abused, they are subject to premature wear and outright failure. This requires costly replacement and worse, serious injury to the handler may result when using faulty equipment.

It is the responsibility of the employees for whom the tools are issued to use, maintain and store them in a safe and proper working condition. Every employee should inspect the tools they will be using for cracks, breaks, or other defects. Defects found shall be reported to your immediate supervisor who will inspect the tools and reject those not suitable.

Measuring devices

Measuring devices such as Brinnel Kits, Probe thermometers and Tong Testers should be checked regularly and adjusted as required. Straight Edges and Taper Gauges should be verified at regular intervals.

Proper use

a) Hand tools must be used only for the purpose for which they are designed.

b) Never operate power tools, appliances, machinery or other equipment before being properly instructed as to their use and care.

c) Keep tools away from the immediate welding zone. Weld spatter will mark and roughen the finished surfaces of tools and painted machine surfaces.

d) Use a “soft” hammer or cushion with wood when striking tempered or case-hardened objects. Never strike hardened tools together.

e) Never carry a sharp or pointed tool about the person unless the point is protected.

Maintenance

a) Ensure that cutting edges on tools do not become dull. Inspection and reshaping by filing or grinding when necessary will ensure the tool does not become “too far gone” necessitating major repair or replacement.

b) Striking faces on hammers, hot cut chisels, punches etc., must not be allowed to mushroom. Tools should be ground to standard by qualified employee.

c) Keep all tools clean and free from heavy oil, grease and rust.

Storage

Tools should be kept in good working order, in their proper place for neatness and convenience. Racks should be provided for shovels, bars, spike mauls and sledge hammers, etc.

Awkward items, which will not stand, should be on shelves or in bins with doors and latches that can be locked. Grinding wheels, welding rods and electrodes should remain in manufacturer’s container when stored. Sharp edged tools should have guards and be stored properly to avoid injuries.

General rules

Hand tools or materials which fail in service or which have suspected or obvious flaws must be reported on the appropriate GO Transit or Contractors’ form for defective material and tools and handled as per instructions on that form.

No alterations to standard tools may be carried out without the approval of the immediate Supervisor.

A Foreman is responsible to have the necessary tools on hand to properly undertake the work assigned. When tools or equipment are needed, requests to the proper authority must be made.

When not in use at the job site, hand tools shall not be placed between the rails nor closer than one meter (3 ft.) from the nearest rail, nor where they may present a safety hazard.

Refer to either GO Transit, the Contractors’ or manufactures’ general instructions and standard plans for information on the safe handling and maintenance of each tool.

Hydraulic hand tools

Figure 3.1 hydraulic hand tools

Inspection of Tools and Equipment

Be familiar with the manufacturers' and/or the company's inspection/operating procedures and specific safety rules for the tools and equipment to be used. Prior to use, tools and equipment must be inspected for conditions that might cause the tool or equipment to fail. Conditions to inspect for include, but are not limited to:

- broke, bent, frayed, deformed, cracked, loose, improperly wedged, or damaged handles (wooden handles must not be taped.),
- cracks, burrs or mushrooming,
- excessive wear or cuts,
- unapproved repairs, missing guards or parts,
- exposure to excessive heat (as noted by difference in color, warped, etc.) that could affect the hardness or temper of the equipment or tool,
- damaged from welding or cutting (as noted by cut marks, pits, gouges,

etc.). Chip protectors must be used on track chisels, drift pins, orsimilar struck

tools.

Employees must not use defective equipment or tools until they are safe to use, and employees must report any defects to the proper authority.

Hoisting Equipment orCranes

Safe Load

Do not overload hoisting and rigging equipment. Do not side-load or drag a load with hoisting equipment. Raise and lower the load steadily and gradually and do not drop or jerk the load or tackle. Remove buckets or magnets from crane when handling loads with slings.

Note: Make sure to use a tag line at all times when handling a load.

Positioning

When working with cranes or other hoisting devices, the ground-man and those in the vicinity must:

- position themselves where they cannot be caught between the load being handled and an obstruction,
- stay clear of loads being suspended,
- not be under the crane boom or similar machine when it is lifting or suspending a load,
- not stand near or in line with a cable, rope or chain under tension or one that might be tightened at any moment,
- walk or stand in the path of a load being handled by a crane, hoist or wrecker.

When equipment is being handled by chains, cables or wire ropes, care must be taken to avoid injury in case of breakage. Loads must not be suspended from booms unless the work requires.

In such cases, keep the load secured and as close to the ground as possible. Loads being transported from one point to another must be landed on a flat car or other conveyance to release the weight from the boom during transit.

If you have any questions or need further help, please contact your supervisor and the proper authority.

Goals & Objectives

1. Safety
2. Quality Work
3. Productivity

Contractors' and GO Transit Track Welders are required to **Safely** produce **Quality**work **Productivly** following all GO Transit welding procedures.

The track welder

All Contractor welders and trainees must familiarize themselves with track and track conditions while on the job.

Be alert ... Ask questions ... Know your territory … Know your job …

AND MOST IMPORTANT WORK SAFELY!!

Chapter 4: Rail Puller-Expander

Introduction

A rail puller-expander is a device used to overcome the extreme contraction or expansion forces present in continuous welded rail due to 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.

Puller-expanders have other uses such as in the repair of rail breaks and pull a-parts, destressing of CWR, and installation of insulated joints. The main use by a welder is to maintain precise rail end gaps during welding operations and the weld cooling off period.

There are a number of types of puller-expanders available commercially, but all perform the same function, i.e. pull together rails in track. Regardless of make or model, all contain the following features:

a) Clamping assemblies to securely grip the rail ends.

b) Hydraulic systems to apply pressure to the clamping device.

c) A device on the pump to control the hydraulic pressures, and the direction of force; either to push or pull.

d) Gauges to indicate hydraulic pressure and to verify that the puller does not leak internally and maintains its holding power.

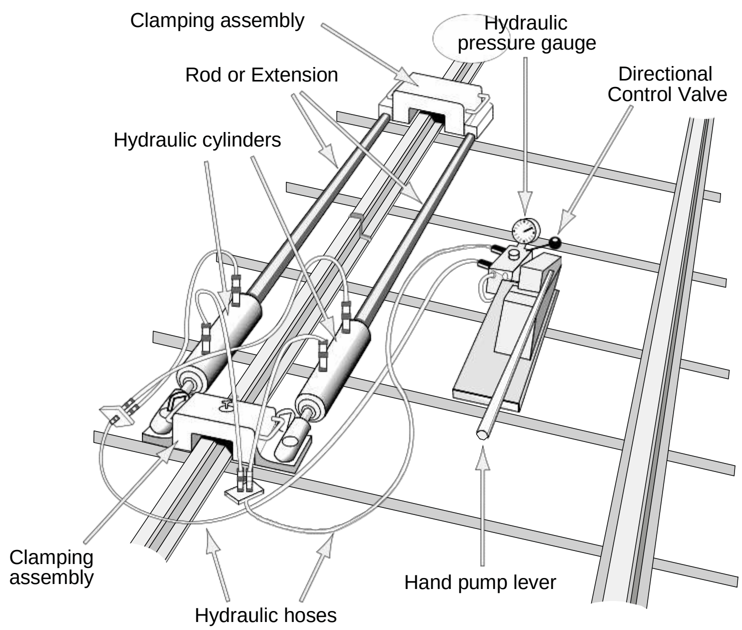


Figure4.1–Typicalcomponents-Simplexhandpump

The hydraulic pumps may be operated manually, or as on some models, small gasoline engines are used.

Operation of hand and power pumps and adjustment must be followed as outlined in the applicable operating instruction manual, for example sheet no. 54065 for Simplex model or the operating and routine maintenance instructions for Permaquip models.

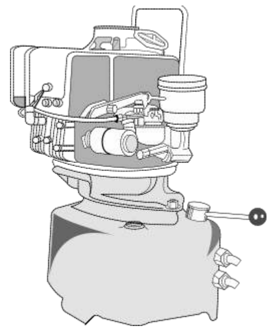


Figure 4.2-Typical gasoline engine driven hydraulic

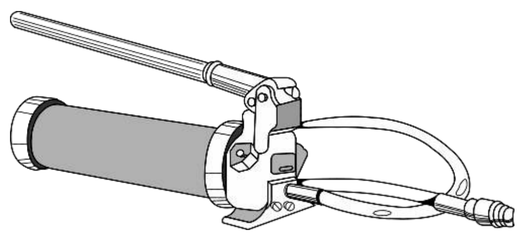


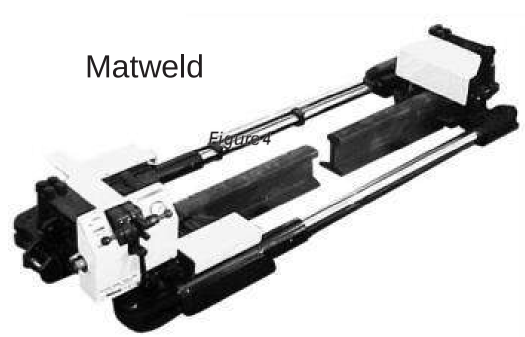
Figure 4.3-ypical hydraulic hand pump

It is essential that welders know how to use a rail puller-expander during thermite welding operations. In particular, they must be thoroughly familiar with the procedure for the safe setting up, operation, and removal from the rail on completion of the welding procedure. In this regard the following general description of puller-expanders and their operation is provided.

Permaquip

Simplex

Matweld



The Permaquip puller-expander comes in two models. Maximum pulling pressures of these two models are 70 and 120 tons, as indicated by the outer red band on the pressure gauge. The maximum pushing force must not exceed 30 tons for the 70 ton puller-expander and 60 tons for the 120 ton puller-expander as shown on the inner scale of the gauge face.

Figure 4.5 Geismar 120 tonpullers

Note:

Even if the instruction manual of the manufacturer says it can push or pull at the same pressure many factors are involved and you should not push because:

1. Track could buckle (sideways or up)
2. An anchor free rail in C.W.R. could build up a pressure up to 160,200 lbs. (dependingon temperature) at each end of the cut rail and damage equipment.
3. If equipment breaks, it could also cause injuries to personnel.

Rail Puller Safety Procedures

1. Carefully inspect all components of the rail puller and related equipment before use. If any parts are worn, damaged, or defective replace them immediately prior to use.
2. This equipment is HEAVY! Use the proper lifting procedures, or devises while handling this equipment. (Use a tagline)
3. Follow and understand all of the manufactures instructions for the safe operation of the type of puller being used.
4. Carefully examine the rail to be pulled for potential snags. (For example: thermite welds, or flash butt welds could 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”. “STAY ALERT”
5. Examine rail web where clamps will contact the web. Thoroughly clean the rail web of oil, grease, or dirt with a non-lubricating solvent, such as those used to clean brake surfaces, or soft torch flame, clean and wire brush. (“Grind the area clean if needed”) DO NOT use lubricating solvents such as WD40 or similar products, to clean the rail.
6. Remove all mill scale from area of clamps. Using a soft torch flame, clean and wire brush. (“Grind the area clean if needed”)
7. DO NOT clamp on rail branding. (Raised Lettering). If unavoidable the branding on the web must be ground off. Care must be taken not to over grind or blue (over heat) the rail.
8. Rail clamp teeth must be cleaned (with wire brush) and inspected prior to each use.
9. While pulling: Make sure all employees stand away from the puller. Only the operator should stand alongside of the puller.
10. While pulling the operator must watch the puller gauge to assure the unit does not exceed the tons of puller force for the capacity design of the puller.
11. If the rail is pulling hard, release the rail puller tension, and pull rail up again. (Additional anchors may need to be removed or heat applied to the rail).
12. DO NOT Remove or apply anchors while the rail puller is pulling.
13. DO NOT Strike any portion of the rail puller, or RAIL while the puller is pulling. Only tap the tie plates to permit the longitudinal force to equalize over the unanchored rail. No closer than 15’ from either end of the puller. (On concrete tie areas, tapping the web of the rail is permitted with a brass or rubber hammer only).
14. After the pull is completed and proper rail gap is achieved the puller must be locked and pressure valve closed. Following all of the manufactures instruction for the type of puller being used.
15. No anchors will be applied within 15’ from either end of the puller.
16. Proceed with the desired application. Stay alert and attentive to your surroundings.
17. While thermite welding: It is recommended that alignment plates, “A” frames, or alignment jacks, be used for setting and adjusting your rail crown and alignment. “Hitting Rail Alignment Wedges may cause the rail puller to slip” “Stay Alert” Keep yourself clear of pinch points. No hitting the rail within 15’ of either end of the puller.

18. Your feet must never be between the rail and the inside of the puller. Always stand or kneel to the outside of the puller while working.
19. DO NOT remove the rail puller until the weld has cooled below 700° F.
20. Follow manufactures instructions for the type of puller being used, to remove the puller from the rail.
21. Inspect, clean, and lubricate the puller as recommended.
22. Load and store in a safe secure manner. (Use a tag line)

Operation – gasoline operated pump

1. With control valve in neutral position, start pump engine. Allow pump engine to idle for several minutes.
2. Operate control valve (to pull rails).
3. Continue pumping until precise rail gap is achieved.
4. Do not allow system pressure gauge reading to exceed rating of the equipment;
5. Stop pump engine (rails will not move).
6. Perform welding operation.
7. Allow cooling period.
8. With pump engine running, reverse control valve position to release grip on rail.
9. To disassemble system:
   a) With pump running, place directional control valve in retract position, slowly open shut-off valve to relieve pressure. Fully retract the cylinders.
   b) Remove pulling screw assemblies from brackets.
   c) Remove push tube assemblies.
   d) Assemble pulling screws to brackets.
   e) Ensure that safety dogs are in down position.
   f) Stand clear of assembly.
   g) Extend cylinder slowly until one or both brackets have come free.
   h) If only one bracket has loosened, it may be used to dislodge the other bracket. Do not hammer on bracket; **hammer on jaws only**.
   i) When driving out jaws, do not straddle bracket or pulling screw. Do not remove pulling screws. Ensure that safety dogs are in the down position. Wear safety glasses.
   j) When all jaws have been removed, then the system may be disassembled.
   k) Fully retract both cylinders and turn off pump.
   l) Disconnect hose couplings from cylinders and pump.
   m) Protect the ends of hydraulic hoses with caps provided or tape securely. Dirt, grit or grime in the hydraulic system will lead to early failure of the equipment.

General precautions applicable to all rail puller-expanders

Hydraulic systems

1. Always keep hydraulic fittings clean, especially self-sealing couplings. Replace all dust caps immediately after couplings are disconnected.
2. Emergency release in event of fluid lock.
3. Check hydraulic fluid level in pump daily.
4. Check hydraulic system for leaks also hoses, couplings, connectors, etc. - arrange immediate repairs if leaks are noticed. Leaks could lead to failure under pressure, which could result in a very dangerous situation.
5. Use only clean hydraulic oil as recommended by manufacturer. Never fill reservoir unless cylinders have been fully retracted.
6. Do not use synthetic fluids, brake fluids, automatic transmission fluids etc., as these fluids will damage the pump.
7. Keep equipment clean - wipe cylinder rams with clean oily cloth. Cylinder rams must be reversed back to original position when not in use.
8. Protect cylinder rams to avoid damage or possibility of scoring.
9. Protect with fireproof sheet during welding. Any accidental weld spatter should be carefully removed by light filing.
10. Always open pump reservoir breather a few turns before use to avoid air locks and close again after use.
11. Couplings must never be disconnected while a system is under pressure. Hose assemblies containing hydraulic oil under high pressure can penetrate the skin and cause personal injury.
12. Be certain the lower plate connecting the jaw assembly is not sitting on an anchor because it may cause the plate to bend and eventually make the jaws difficult to open.

Important notes: Do:

- Store rail expanders off the ground.
- Check contents before going out to use it.
- Assemble in correct order.
- Make sure all link pins are properly installed.
- Pump in rams after use.
- Treat hoses with care - your safety may be at stake.
- Use emergency relief valves if hydraulic resistance is met.
- Lubricate the rams with light oil after use.

Don't:

- Let sets go rusty.
- Use any hydraulic fluid other than that recommended.
- Put point oil or water in the hydraulic pump.
- Hesitate to ask when in doubt.
- Forget – negligence costs money.
- Attempt to remove hydraulic couplings while equipment is under pressure.
- Forget you may be using it next time.
- Forget to clean serrated edges of wedges after every use (use hacksaw andwirebrush).

Note: Do not strike or hit the rail within 15 feet of the rail puller.

When making two welds on a plug, the rail cannot be pulled for the second weld until the initial weld has cooled below 700^{o}F(371^{o}C).

Chapter 5: Types of Grinding Equipment, Safety, Usage and Specific Finish Dimensions

Introduction

The module you are now starting will be in three parts. In part one, you will find engine and electrical driven tools, in the second part, you will find the part on High Frequency, and the third part will be on abrasive wheels and finish dimensions.

Part 1 – Tools

Grinding of track components

Grinding of track components is necessary for two reasons:

a) As the best preventive measure to reduce the need for welding.

b) For preparation and finishing when welding is required.

To perform this work accurately and efficiently, several grinding machines are available.

It is the operator's responsibility to learn the operation of each piece of grinding equipment in his charge and to ensure its safe and proper use. The machines listed herein must be maintained as per the manufacturer's and the following instructions.

Four cycle engine driven

The following grinding machines are powered by four cycle gasoline engines:

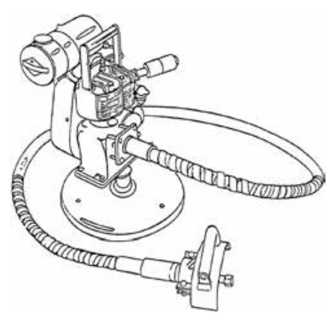


Figure 5.1

General care

a) Lubricate and wipe all moving parts daily before use.

b) Apply a light film of graphite on machine tracks and outside of rollers if or when required.

c) Check engine oil level before every start and change oil at least after every 25 hours of operation or as conditions warrant.

d) Wipe off excess grease and oil, which may gather grinding dust and work into bearings and moving parts.

e) Maintain air cleaners in good condition; inspect regularly and replace them as oftenas necessary.

f) Inspect the entire machine before use to ensure all bolts are tight. Be certain theabrasive wheel guard is in place and properly adjusted and fastened.

g) Align the flexible shaft as straight as possible during working operations. A sharp bend may damage the shaft or shaft casing. Store flex shafts within the casing, ends protected, lying flatto their full length.

h) The governor must not be tampered with. A tachometer must be employed periodically to assure a safe abrasive wheelspeed.

i) Drive belts must be in proper adjustment and on multiple belt drivers all belts must be in place and of equal tension.

j) When transporting or removing a grinding machine from the track, retract the abrasive wheel so that it is not damaged.

Electric grinders

Electric hand grinders

There are two types and both operate on 110 volt AC from a conventional AC power source, an AC generator or the AC outlet on an arc welding machine.

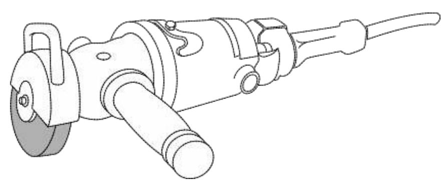


Figure 5.2 Straighthandgrinder

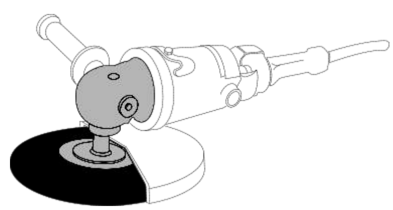


Figure 5.3Anglehandgrinder

General care of electricgrinders

a) Keep cable, switch, attachment plugs and body free from grease and oil.

b) Inspect regularly and repair breaks in cable insulation or connections immediately.

c) Do lubricate.

d) Clean the entire machine periodically to prevent the accumulation of grinding dust.

e) Ensure abrasive wheel guards are properlyattached.

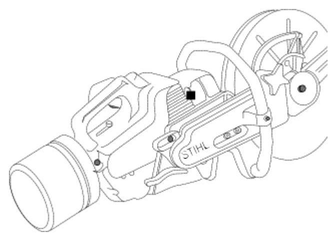
f) Hang grinders in cabinets as opposed to laying them on the truck box floor; this will prevent damage to the stones.

Two cycle enginedriven

a) Quick Cut Slotter

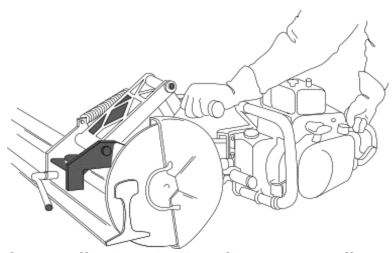
b) Abrasive Rail Saw

These machines are powered by two cycle engines and require a gasoline and oil mixture to fuel them. Unleaded gasoline or gasoline containing methanol (see note) is not to be used in a two cycle engine. Shake the fuel container thoroughly before refillingtank.



Fuel: Regular gasoline TwoStroke Oil, 25:1 (25 parts gasoline; 1 part oil)

Figure 5.4 QuickCutSlotter



Fuel: Regular gasoline SAE 30, 25:1 (25 parts gasoline; 1 part oil)

Figure 5.5 AbrasiveRailSaw

General care

a) Air filters must be checked before use. Replace as often as necessary.

b) Inspect and tighten all bolts and V-belt tension at regular intervals. Clean the entire machine when necessary paying special attention to the cooling fins.

c) If the machine has not been used for a long period of time, oil will separate from thegas-oil mixture. Therefore, shake the machine thoroughly before starting the engine.

d) When operating, wheel guards must be securely in place.

e) Ensure safe abrasive wheel speed. A tachometer must be employed periodically.

Note:

Gasoline, which contains methanol, must not be used in hand held powered equipment as it has a very high expansion factor (three times that of regular gasoline). Only regular unleaded gasoline should be used.

Part 2 - High frequency equipment

Introduction

Some welding equipment is equipped with high frequency motor drives.

Figure 5.6

The purpose of this reduced section of the original course in our module is to take another look at what high frequency equipment is, how and why it is used, the safety and maintenance aspects of the high frequency equipment and tools.

High frequency equipment

The Equipment package contained the following:

- High frequency welding machines are equipped with an auxiliary three phase power winding to supply power to the motor drive.

Figure 5.7

The following group of power tools:

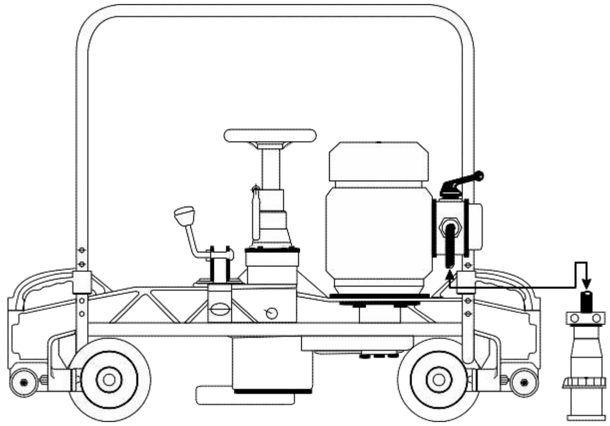


Figure 5.8-MP-12 Railgrinder

Figure 5.9 - MC-3(HF) Switch and stock rail grinder

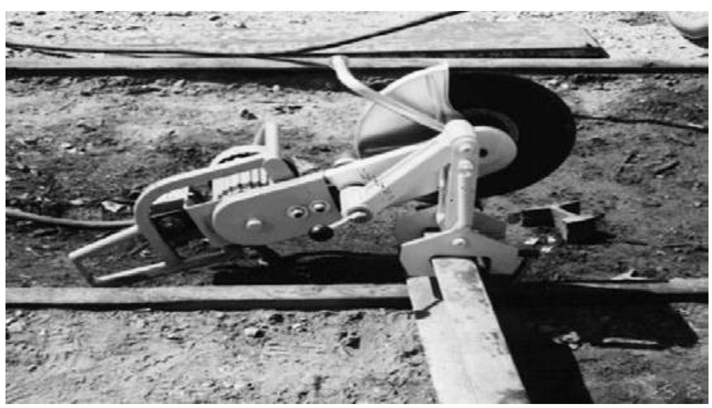


Figure5.10-MTX-45(HF)Railsaw

Figure 5.11 – Bosch (HF) Straight handgrinder

Figure 5.12 – Bosch (HF) Angle handgrinder

Face-shield, shin-guards and hearing protection required.

The proper operation and maintenance of all of the above equipment is essential for providing safe and continuous service from this equipment.

What is high frequency?

True high frequencies are upwards of 15,000 to 100,000 cycles per second (expressed as 1.5 to 10 megahertz). They are not transmitted through wire.

Example:

Microwaves, such as used in a microwave oven, are an example of true high frequency electricity.

Comparison of the "High Frequency" in the motor drive to household electricity

To give you a better understanding of what we are calling 'high frequency', we'll compare it to something that you are more familiar with: household electricity. Household electricity in North America is 220/110 volts, 60 Hertz, single phase. That means the frequency of the cycles is 60 per second.

The drive outputs electrical cycles at a more frequent rate or higher frequency than normal household current:

- 300 Hz or 300 cycles per second, 3-phase.

The water system analogy

To help understand the basic electrical concepts, we will compare electricity to a water system.

- The amount of water in the reservoir is creating the pressure on the water system (voltage).

- The piping represents the conductors (often called wire).
- The flow of water running through the pipe at a given point is the current (amps).
- Any factor that reduces the flow of water is called resistance.
- The force at which the result is produced is the power.

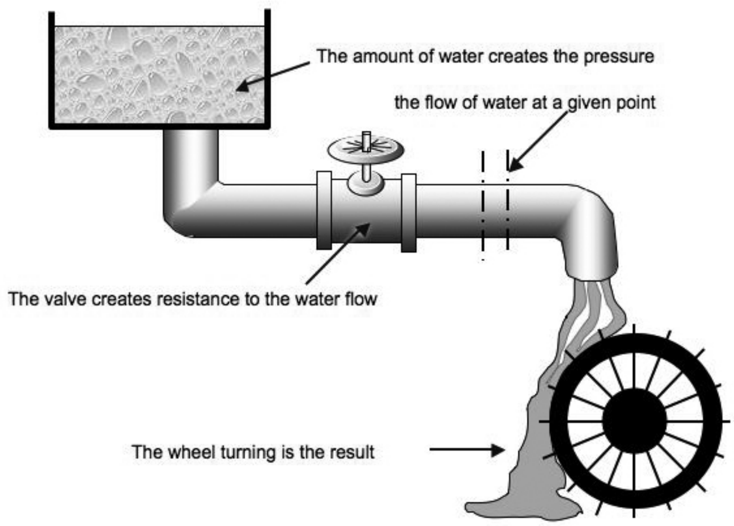


Figure 5.13

Electricity works the same way as a water system shown in the above illustration. The difference is that instead of being water flowing through pipes, electrons are flowing through conductors. Electrons are very small particles that are easily pushed to produce electricity.

The electrical circuit

To get a result from electricity you need a complete circuit.

The energy going to an electrical device needs a return path to its source to be able to flow. Without the return path, the circuit is not complete and there will be no electrical result or reaction. But remember that there will still be electrical pressure (voltage) in the conductor even if there is no flow (current). The same as in the water system analogy, if you close the valve, the pressure is still there.

If the motor switch is in the OFF position, there is still voltage present at the motor; but, because there is no return path, the motor is not running.

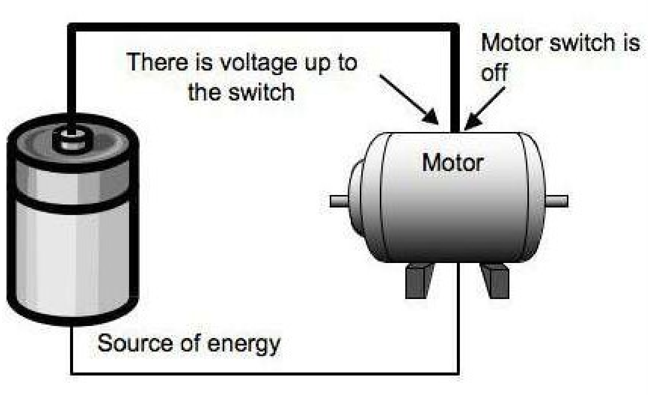


Figure 5.14

Why do we need the motor drive box?

Since we're using a generator to provide power, its speed would normally provide us with the frequency of our current. The current from the generator into the drive box is at 60 hertz. To achieve this we must run the engine turning the generator at 1850 rpm.

The drive box converts the incoming 3-phase 60 hertz current from the generator to 3-phase 300 hertz output for increased power and efficiency. The drive box provides us with an increase in frequency without affecting the speed of the generator engine. Without the drive box, we would have to run the engine at a constant 9250 rpm to achieve 300 hertz. This is impractical and inefficient.

The increase in frequency, in combination with 3-phase cycles, provides more efficient and smoother power output so that high frequency tools can be used.

Why use higherfrequency?

By using higher frequency, it is possible to get a lot more power from a motor without increasing the current flow.

High frequency motors have little or no speed change under varying load conditions. High frequency tools offer 5 times the torque of standard electric tools, so there is little chance of stalling the tool.

Is this higher frequency (300Hz) dangerous to my health?

The higher frequency current of the drive box is no more dangerous than normal household current. Yes, you can get a shock if proper safety precautions and practices are not followed; but the same holds true for household current. Operating a high frequency tool is no more dangerous than operating a power tool or appliance in your home.

Furthermore, this is proven technology. The use of a 300 Hz motor drive is relatively new at GO, but has been in use in other industries for years to obtain maximum power with minimum amperage:

Examples:

Auto manufacturers, US railroads, Manitoba and BC Hydro

Why use 3-phaseelectricity?

Three-phase power is the most commonly found electrical system in industry because it allows for:

- a simpler motor design than that of a single-phase motor.
- a more efficient and longer lasting motor.
- a smaller and lighter motor.
- more stable current.

A three-phase system pulls less current per wire than a single-phase system.

Why high frequency, 3-phase Electric Motors?

***Advantages**:*

- Smoother output and increased power to the tools:
- There is very little power loss (about 5%), even when using a 100 ft. extension cord.
- There are lower operating costs when compared to 2-cycle engines or hydraulic tools.
- Virtually no maintenance is required for the electric motors.
  - Bearings need to be changed every 5,000 hours.
- Grinding dust will not affect motor operation.
  - Two-cycle engines require frequent air filter changes, otherwise engine damage will occur.
- No carburetor adjustments are required for proper motor speed.
- The need for various fuel containers to accommodate the different fuel-to-oil ratio of2-cycle engines is eliminated.
- High frequency motors are more environmentally friendly:
  - There are no exhaust fumes.
  - No danger of fuel spillage causing fire or an explosion.
- There are lower noise levels, and therefore, increased operator safety:
  - Better hearing conservation.
  - Operators can hear trains and equipment approaching.

Disadvantages:

- The power cord is heavy and takes longer to set up than a gas-powered tool.
- The electric motors are heavier than the 2-cycle engines.
- Only one job can be performed at a time.

- No grinding and welding at the same time.

(We'll explain more about this under 'Grounding'.)

- Though problems occur less often, when one does occur in the drive box, none of the tools are to be used until the equipment is repaired.

Electrical safety - Grounding &bonding

Proper grounding and bonding of equipment will prevent tools and all metal enclosures from becoming electrically energized in the event of a ground fault.

Important Note:

When the word 'ground' is used, this does NOT mean that the current is looking to go to earth. Actually the current is trying to go back to its source, and will always take the least resistive path to it.

Grounding ofequipment

Proper grounding is essential to ensuring the safe operation of any electrical equipment, whether it be a home appliance or a tool manufactured for use with a high frequency drive.

When a conductor touches the metal enclosure, the path to ground (which is necessary for the circuit protective device to function) is through the green, grounding conductor wire.

Important:

Unless all of the elements of this system are properly connected, the protective device will not function! Always make sure that the grounding conductor is properly connected and in good condition.

There is no way of knowing whether or not the grounding wire is connected without visually inspecting the connections!

An incorrectly wired ground is dangerous because, if one of the line wires and the safety grounding wire have been transposed, the shell of the tool is "hot" the instant the plug isconnected.

All new tools, properly connected, use the green wire as the grounding connector: This wire is attached to the metal case of the tool at one end and to the grounding pin in the connector at the other end. It normally carries no current, but is used only when the tool insulation fails. In that case it short-circuits the electricity around the user to ground and protects the user from shock.

The green wire must never be switched with the other colored wires, which are the true current-carrying conductors.

Heat in a motor or tool

Heat is detected at the motor or tool means that the motor is not running at its normal speed. Insufficient current being sent to the tool or the tool is working harder than it was designed for could cause this.

In both situations this generated heat will eventually cause irreversible damage to the motor. When heat is sensed at the motor, ensure that:

- the drive is in the proper ‘run’ position for the tool (low/normal switch).
- all cables are in good condition.
- no heat is detected on the connectors.
- the tool is being used properly.

Heat in cables/connections

Resistance to current generates heat. Whenever heat is felt, either on the cable or connection, this means that there is resistance to current present.

This resistance could be caused by: a loose connection, a partially broken wire, bad wire insulation, or a motor that is not turning at its proper speed. If heat is felt on a conductor or plug, do not use the cable until you inspect the connections or the insulation.

Figure 5.15 - Typical Tweco connectors

Note: The female connector must always be on the cable end closest to/from the power source.

Bonding of equipment

Effective bonding means that the electrical continuity of the grounding circuit is assured by proper physical connections.

Bonding provides a pre-arranged path for electricity to travel through, in the event of a ground fault or short circuit.

Insulation

Cable insulation

The insulation covering the cable is very important. Cables must be handled carefully to prevent deep nicks and scratches.

Once the insulation on a cable is seriously nicked, the insulating capacity of the cable is reduced: Heat will start to dissipate, eventually burning the insulation and causing a ground fault.

Splicing of cables and extension cords should never be permitted for the same reason. Electrical tape, no matter how thickly applied, does not have sufficient insulating capacity for the current.

If a cable is damaged, don’t use it; replaceit!

What is a groundfault?

A ground fault occurs when a live conductor accidentally leaks to the ground system. A ground fault differs from the more common phase-to-phase fault (short circuit), in which the live conductors come in contact with one another.

Examples:

- Insulation failure.
- Contact between a live conductor and the equipment enclosure.

The normal return path of a ground fault is through the green, grounding conductor wire, which, by design, has a low resistance.

Ground return path

Grounded equipment

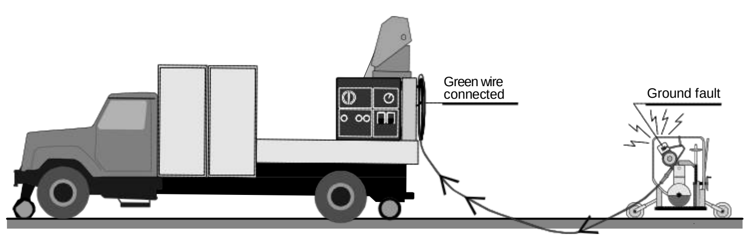


Figure 5.16 - Groundfaultwith groundingconductor inplace

Figure 5-16 above shows the ground-fault return path occurring when one of theconductors comes in contact with a metal enclosure (i.e., ground fault).

When a ground fault occurs that allows the live conductors to contact the metal housing of grounded electrical equipment, and a person touches a part that is accidentally energized, there will be no shock.

The grounding wire, not the person, furnishes the path of least resistance to ground.

Ungrounded equipment

When a ground fault occurs that allows **the live conductors to contact the metal housing of ungrounded electrical equipment**, any person who touches that equipment will receive a shock if he or she completes the circuit back to the generator.

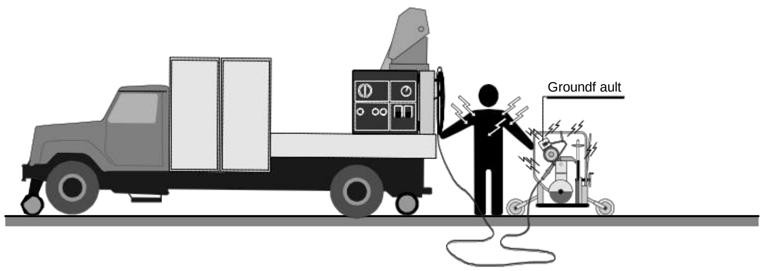


Figure 5.17 - Groundfault with no groundingconductor inplace

Current will always take **the path of least resistance to go back to its source**, which, in this case, is the generator.

If the green wire is disconnected, it no longer provides that path.

A special case: Return path of the weldingmachine

It is a mandatory practice to always disconnect the cable when a high frequency tool is not in use and you must ensure that the ON-OFF switch is in the OFF position when you are in a welding mode.

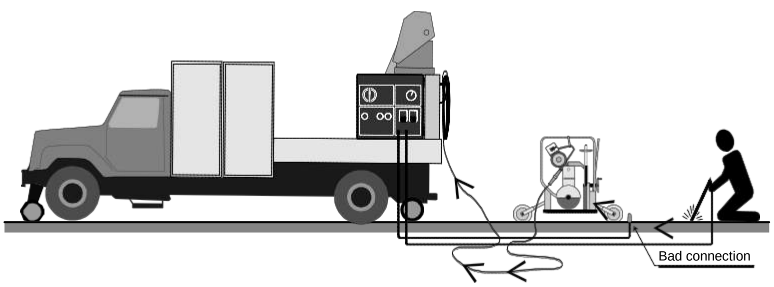


Figure 5.18 - Welding Machinegroundingreturnpath accidentallypassingthroughextensioncablegroundwire

By design, this wire could only withstand 30 amps. In normal operation, a welding machine may be working with between 100 and 300 amps or more.

So, to be safe, make sure you disconnect the cable when the tools are not in use… make it a habit!

The physiological effects (table) of electrical shock

The following table shows the physiological effects of various current densities. Note that voltage is not a consideration. Although it takes voltage to make current flow, the amount of shock-current will vary, depending on the body resistance between the points of contact.

Readings		Effects
Safe Current Values	1 mA or less	Causes no sensation - not felt.
	1 mA to 8 mA	Sensation of shock, not painful; individual can let go at will since muscular control is not lost.
Unsafe Current Values	8 mA to 15 mA	Painful shock; individual can let go at will since muscular control is not lost.
	15 mA to 20 mA	Painful shock; control of adjacent muscles lost; victim cannot let go.
	20 mA to 50 mA	Painful, severe muscular contractions; breathing difficult.
	50 mA to 100 mA	Ventricular fibrillation - a heart condition that can result in instant death - is possible. Ventricular fibrillation occurs.
	100 mA to 200 mA 200 mA and over	Severe burns, severe muscular contractions- so severe that chest muscles clamp the heart and stop it for the duration of the shock. (This prevents ventricular fibrillation.)

Figure 5.19

Remember that 75 volts are just as lethal as 750 volts.

Resistance of the body

The actual resistance of the body varies, depending upon the points of contact and whether the skin is moist or dry. The area from one ear to the other, for example, has an internal resistance (which is lower than skin resistance) of only 100 ohms. From hand to foot, it is nearer 500 ohms. Skin resistance may vary from 1000 ohms for wet skin, to more than 500 000 ohms for dry skin.

A well-grounded system is important to the safety of the person using electrical equipment.

General safety precautions

- Follow all safety rules concerning welding and grinding.
- All wires and conductors are to be considered alive at all times unless the employee has positive knowledge to the contrary.
- Do not work on ungrounded equipment.
- Keep one hand in your pocket while investigating inside an electrical box.
  - Most importantly, do not touch live electrical equipment inside the box.
- Never grasp or place both hands simultaneously on electrical boxes:
  - If a ground fault has occurred, the panels or equipment are carrying the fault current to ground (as previously explained in the grounding section). The protecting device will not operate to open the circuit if a high resistant connection exists in this path.
  - By placing a hand on each side of the high resistant connection, the potential difference will cause a current flow through your body.

Electric welding and high frequency equipment

1. All power wiring to welding machines should be installed and maintained in accordance with the Canadian Electrical Code.
2. Always be sure that the power to the machine is shut off before making any repairs or adjustments, as the high voltage used for arc-welding machines can inflict severe or possible fatal injuries. For those using High Frequency Equipment, make sure you know the equipment and understand the basic principle of how it works. See course for "Welders on High Frequency Equipment."

   Do not play with what you don't know.
3. **Be sure your machine is properly grounded. Stray current causes severe shock when ungrounded parts arctouched.**
4. Do not use pipelines carrying gases or flammable liquids and conduits carrying electrical conductors for grounding purposes. Be sure conductors can safely carry the ground current.
5. Never change the polarity switch nor throw the rotary switch when the machine is under load. Wait until the machine is idling and the circuit is open or you will probably damage the contacts.
6. Do not make welding current adjustments, which involve breaking the welding circuit, while the operator is welding.
7. Don't let the electrode holder contact the welding ground; this will cause a dead short circuit on the welding generator.
8. Keep cable connection at the electrode holder tight. A loose connection causes excessive overheating.
9. Don't overload welding cables or operate with poor connections. Operating with currents beyond rated capacity causes overheating, while poor connections cause bad welds.
10. Don't work in a damp area. Keep hands, clothing and work area dry at all times.
11. Avoid contact with electrical leads, particularly when perspiring.
12. Again... never strike an arc on a compressed gas cylinder. Serious fires and explosions have been caused this way. Keep electrodes, electrode holders and other live parts away fromgas cylinders.
13. Check the condition of your helmet and hand shields for cracks. Replace defective parts.
14. Never look at the arc with the unprotected eye. Wear flash goggles with side shields at all times, even when adjusting controls, etc.
15. Be sure that helmets and hand shields are equipped with the proper type of filter plates.
16. Never strike an arc if there is somebody near you who is not protected. Use anon-reflecting screen to protect others working nearby.
17. Remember: Be sure there is plenty of fresh air from blowers, air lines or other means, while welding in closed or confined places. Never use compressed oxygen for ventilation.
18. When toxic fumes from such as lead, zinc or cadmium bearing materials or any other substances are present in harmful concentrations, always use an air supplied respirator.

19. Do not weld in the presence of Trichloroethylene or Perchloroethylene vapors. The electric arc can break down halogenated hydrocarbons to form phosgene, which is a health hazard. Ultra-violet rays will also decompose triehloroethylene or perchloroethylene vapors at considerable distances to form phosgene in much greater amounts.
20. Never operate a gasoline powered welder where you cannot get rid of the enginefumes. Carbon monoxide will kill or seriously injure.
21. While arc-welding, wear leather welding gloves, fire resistant apron and adequate clothing to protect the skin against the heat, spatter and sunburn of the arc rays. Woolen clothing is preferable to cotton, while garments made of synthetic materials and oily, torn or frayed clothing must not be worn due to their flammable nature.

Maintenance schedule

Scheduled maintenance

This section will deal with the maintenance of the High Frequency converter box, the extension cable, plugs and receptacle, and the tools that are utilized. This section will be broken down in to sections based on time intervals that maintenance shall be performed.

Daily maintenance

The following maintenance procedures are to be performed every day.

Plugs

- Perform a visual inspection of the plugs on both ends of the extension cable and at the tool.
- Check the cable retainer and be sure that all screws are in place and that the cable is not loose where it enters the plug.
- Looking into the plug, examine the prongs in the male end of the plug, checking for bent, broken, corroded or discolored prongs, and check that all screws are in place.
- Check that plug coupling is tight and will not rotate.

Cables

- Inspect full length of extension cable looking for cracks or breaks in the rubber casing.
- Look for areas that may have been squashed or bent.
- Check for wear marks around areas that may be rubbing (i.e.: on the truck body, etc.).

If you suspect that there may be a problem with a cable, contact the field maintainer for further inspection.

Tool inspection

This section of the daily inspection includes only the portion of the equipment related to the High Frequency drive box and the components associated with the electrical equipment. If you have guidelines regarding inspection of grinding stones and abrasive saws etc., continue with those procedures as well.

- Check plug and cable on tool as outlined previously.
- Check the point where the cable enters the junction box, be sure that the grommet nut istight and that the cable cannot rotate freely in the grommet.
- Check the handle on the switch to be sure that the handle operates properly. Turn handle to “on” position and then “off”; be sure that it comes to a definite stop.
- Check that handle is tight and secured to the switch.
- Check that all screws are in place on the junction box cover.
- Visually check for loose or broken bolts where motor mounts to frame of tool.
- Look for signs of damage that may of occurred during transport, or vandalism.

If you are unsure as to the condition of equipment contact the proper authority for further inspection.

Weekly maintenance

Outside the converter box

If daily inspections of the converter box are carried out, any problems with the enclosure will be minimal.

The bolts, which hold the converter box to the welding machine through the rubber vibration dampers, should be checked for tightness. Check the bolts that mount the welding machine to the truck body; be sure that they are in place and tight.

Plugs

Tighten cable retainer screws; if coupling is loose, remove screws and turn coupling clockwise until it is snug; reinstall retainer screws and tighten.

Cables

Daily inspection of the cables is required and immediate repair of any defects is to be performed. Do not wait one week to inspect the cable, as serious problems could result.

Tools

Tighten electric motor mounts using the proper wrench (9/16). Remove junction box cover and check the connection of the grounding conductor (green wire) to the side of the junction box, tighten if necessary.

While the cover is off the junction box, check the rubber seal around the cover for any tears, breaks or deterioration of the rubber. Clean grinding dust and dirt from around electric motor.

Part 3 - Abrasive wheels and finishdimensions

Inspection of abrasivewheels

1. A visual inspection must be made of every wheel, either new or used. Watch forcracks, large nicks and obvious imperfections.
2. As an added precaution, tap the wheel gently with a non-metallic object (such as the handle of a screwdriver). A sound wheel will have a clear “ring”. If in doubt, compare the sound with that of other wheels of the same lot. Discard wheel if necessary, attach a completed Defective Material Report and deliver to supervisor.

Storage of abrasive wheels

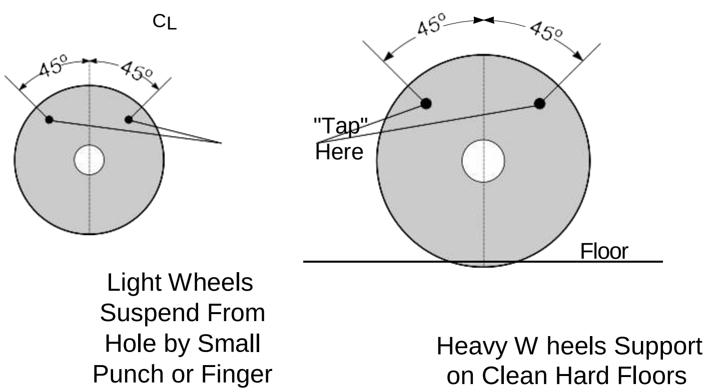


Figure 5.20

Abrasive wheels must be protected while awaiting use.

1. Arrange storage to allow wheel selection:
   a) Without disturbing other wheels.
   b) Without damaging other wheels.
   c) With a minimum of handling.
2. **Store in a dry area not subject to extreme temperature**. Abrasive wheels areporous and will absorb moisture. Freezing may damage thewheel.
3. Thin organic bonded wheels (slotting and cutoff wheels) should be laid flat on a perfectly flat horizontal surface away from excessive heat to prevent warpage. Itis suggested that they be stored:
   a) On heavy flat steelplate.
   b) Without blotters between the wheels.
4. Store large straight wheels on a clean, dry floor, not piled over (3 feet)high.
5. Straight cup wheels may be stacked on flat sides with some sort ofcushioning material between them.
6. Flared cup wheels should be stored in boxes, bins or drawers. Do not rest or fit one inside the other. A layer of cushioning material should be between each layer of wheels.

Mounting of abrasivewheels

1. Ensure that it is the proper wheel for the machine and that the spindle speed does not exceed the recommended operating speed of the wheel.
2. Fit - Wheels must fit freely without play. Do not force on. Do not alter hole.
3. Flange Washers - Must be true and free from nicks and gouges. Use clean, recessed, matching flanges of at least 1/3 the wheel diameter.
4. Blotters - One clean, smooth blotter on each side between wheel and flange washer.
5. Bushing - If used, must not extend beyond side of the wheel.
6. Securing the wheel - Tighten nut(s) only enough to hold the wheel firmly.

Using wheels

1. Required PPE must be in place before starting the machine. Proper wheel guards must be in place and properly adjusted per ANSI code. Guards are not to be removed or altered.
2. Stand aside and allow the wheel to run at operating speed for one full minute before applying to the work.
3. Make grinding contact without bumping or impact. A cold wheel must be applied gradually giving it a chance to warm up.
4. Never exceed the maximum speed marked on the wheel.
5. Cut-off and slotting wheels may break under excessive side pressure. Use all grinding wheels with this caution in mind.
6. Keep flammable materials away from the work area. Spark direction must not be toward gasoline engines.
7. In the event of wheel failure, make a full inspection for cause and damage. Check equipment and make any needed repairs before continuing work.
8. Abusive finish grinding of cold rail steel, particularly chrome and alloy rail, may create a layer of martensite of an average hardness of over 600 Brinell, causing a potential defect origin site. The principles of basic Metallurgy must be observed.

Finish dimensions and precaution in track grinding

Stock rails

To repair weld and grind a 30” section (the maximum length permitted) takes about 2-1/2 hours. It is preferable to repair stock rails before the repair length reaches 15”. Stock rails should be repaired only once.

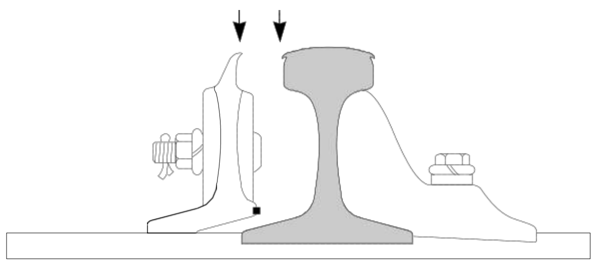
The repair of the wheel transfer section of stock rails was reviewed (Mar. 89) and a standard procedure developed. We will deal specifically with the grinding aspects here. Welding is covered in handout but the following few points have a bearing on grinding.

Prior to welding, remove defective surface metal by grinding, being careful not to grind an excessive amount. Under no circumstances may arc air gouging or oxyacetylene cutting be employed in place of grinding.

On completion of the welding work, grind to level and contour using an MP12 Grinder. Do not use excessive pressure so as to cause bluing of the metal.

Abusive finish grinding of cold rail steel, in particular chrome rail, will create a layer of untempered martensite of an average hardness of 600 Brinell, while the weld metal is only 300 Brinell, which creates a potential defect origin site. The principles of basic Metallurgy must be observed.

Flowed metal along the field side, planed portion of switch points and the gauge side of stock rails must be removed to leave a complete and proper mating surface between these components. A slight rounding of the uppermost ground surface should then be done in order to retard further flow of metal.



Grind all Metal Overflow at Gauge and Field Side of Stock Rails and Switch Points

Figure 5.21

Note

GO Track Standard 12.4.7states “Flow not exceeding 1.5 mm (1/16 inch) on switch point or gauge side of stock rail.”

The gauge side of the switch point may be ground only by the use of a stock rail Grinder or a hand held grinding head. Grind the full length of the point if necessary to remove metal flow and taper out a few inches past the heel joint.

Metal flow along the field side of the stock rail should also be removed leaving the upper edge rounded, similar to a new rail.

Metal flow along gauge side of the stock rail shall be removed and top radius restored well beyond the switch point contact area. Special attention in this regard must be observed when grinding Samson points and stock rails, not to alter the mating faces. Free hand grinding is forbidden.

Rail adjoining guard rail

Metal flow on the running rail next to the guard rail must be removed to ensure proper track gauge. Gauge side of the running rail should be ground well beyond the length of the guard rail and then tapered out to allow for smooth wheel flange travel. The upper edge of the rail head must be rounded to proper radius to limit further metal flow.

Care must be exercised to remove flowed metal only, so that track gauge is not distorted due to excessive grinding.

Surface grinding

1) *Thermite welds*

Improper grinding practices can lead to eventual failures in thermite welds. Care must beexercised to observe correct procedures. Abusive grinding may result in gouges or sharp notches in the weld. Flexing of the weld under load may eventually lead to rail failure.

Another common failure is caused by excessively coarse grinding wheels creating deep grinding gouges, which are flaw initiators! As a rule of thumb, grinding gouges must not be so deep that the ridges created roll over under traffic. All TW grinding wheels meet this requirement. Do not use unapproved grinding wheels.

All welds must be finish ground after cool-out.

a) Running surface tolerance is +0.25 mm, - 0.15 thousands high nothing low.

b) Sides of head flush. Any variation blended in.

c) Base edges flush, corners slightly rounded.

d) Ensure there are no grinder gouges, burns or sharp notches in the web / base fillet of thecollar of the thermite weld.

e) All base risers must be ground flush with weld collar. This will ensure weld quality, and any sharp edges removed to prevent premature weld failure, NOTE: The only exceptions are inthe areas between switch points and stock rails and toe and heal of frogs where the hand grinder will not fit.

2) *Welded rail end-joints*

a) Finish ground level across joint conforming to existing rail contour. Variations blended in.

b) Running surface tolerance is + .010” - 0”.

3) *Engine burns and repaired stock rails*

a) Tolerance +.010” to 0.000”

b) Any flow of metal on the gauge or field sides of the rail head at the repaired area mustbe removed, and blended to existing rail contour.

Frogs and diamonds

Flowed metal, which reduces the flange-way dimensions of frogs and diamond crossings, will crack or spall if not removed.

Flange-ways should be cleared of flowed metal to a standard 48mm (1 7/8 inches) clearance and with the walls of proper slope. The gauge edges of frog points and wing rails should be ground to retard flow and retain the top surface metal in compression. In order to determine the accuracy of frog and diamond contours an approved flange-way gauge must be used.

Spring frog, sliding joints, SGM’s, diamond inserts, rigid frogs, regular point frogs should be ground to a 3/8 radius

Heavy point RBM, joint-less boltless manganese (JBM), welded heel manganese (WHM), MPF frog castings grind to 9/16 radius .

To eliminate overflow and prevent spalling along the rail contact bands or mating surfaces of frogs and diamonds, overflow must be removed by use of a slotting wheel to a depth of 6 mm (1/4”).

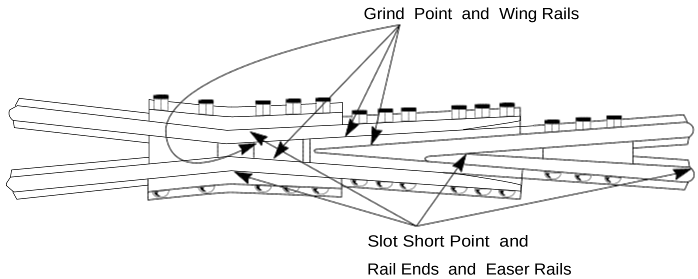


Figure 5.22- Rigidfrog

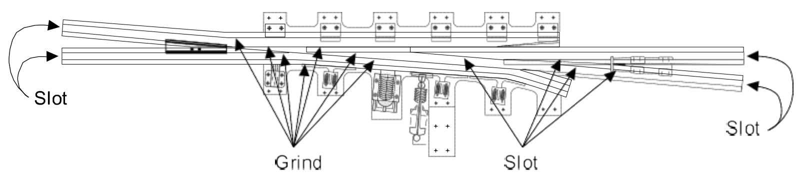


Figure 5.23- Spring frog

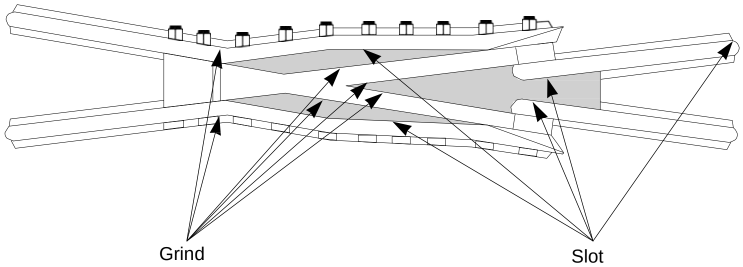


Figure 5.24- R.B.M. frog

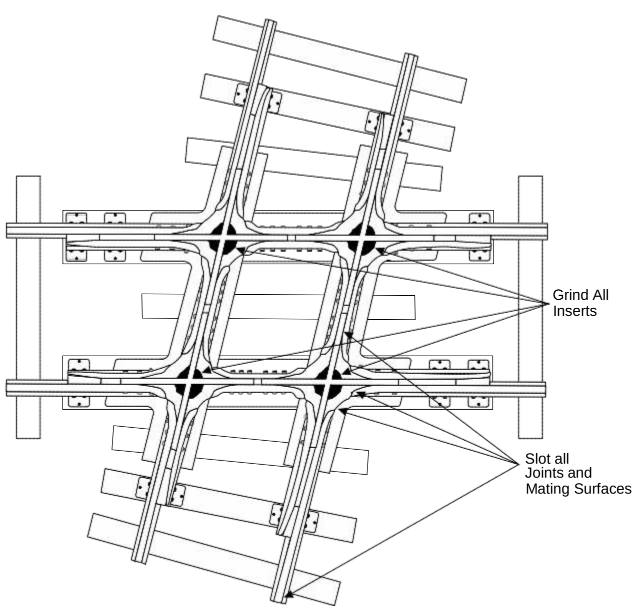


Figure 5.25- Reversible insert manganese diamond

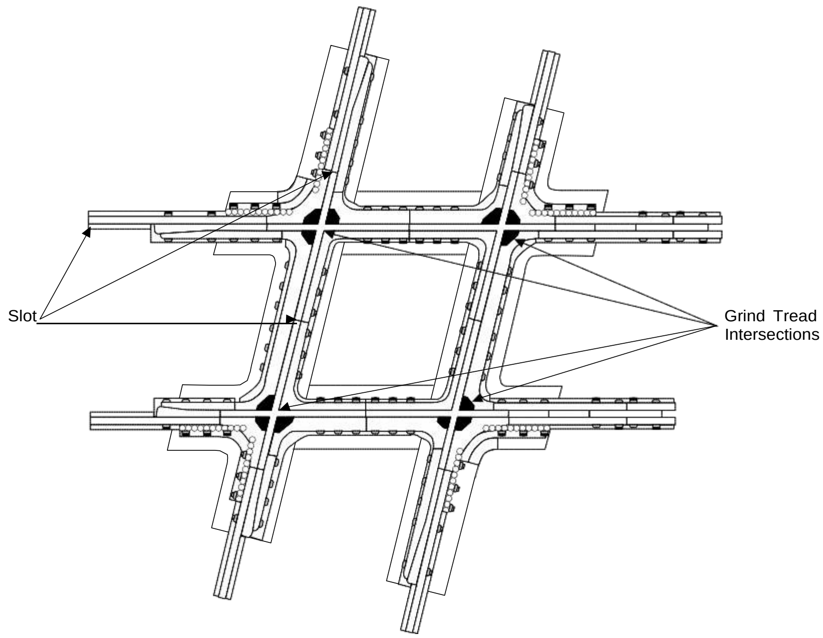


Figure 5.26 - Solid manganese diamond

Slotting of rail ends

Refer to GTS Plan 1113 for slotting dimensions governing each type of joint.

Fire protection

Protect against fires, which can be caused by slotting, by having the appropriate fire suppression equipment available and ready for use.

Preventive measures

1. When working on live track operating any equipment, it is essential that one employee act as a dedicated lookout, this is known as the "Watchperson/Lookout."
2. The dedicated lookout person must never engage in other tasks, which could interfere with the responsibility of protecting others, but must watch for oncoming hazards in all directions.
3. The proper eye protection is required to prevent arc flashes. The minimum color grade is welder's green 3 but 5 is preferable.

Remember:

The safety watch – is a watch for life!

Chapter 6: Electric Arc Welding Power Sources, Accessories, & Maintenance

Introduction

All arc-welding processes require a continuous supply of electrical current in sufficient amount (amperage) and of the proper voltage to maintain an arc. This special electrical power may be produced from a variety of welding machines. This chapter deals with the machines and accessories, which are commonly used by railways and, in particular, by a railway welders.

At the end of this section, you will be able to safely set up a welding machine, set the amperage, and hook up the ground and electrode cables properly. You will also be familiar with the main types of welding machines and the currents they produce.

To weld successfully with electricity, you need a welding machine that will control the current and which can be handled safely.

The two main types of welding machines used are DC welding machines, which produce direct current, and AC welding machines, which produce alternating current. There is also some AC/DC welding machines that can be adjusted to produce either AC or DC current.

Many different manufacturers produce welding machines, and while they may have different switches, dials, adjustments, or extra features, all welding machines have the same basic features and work the same way.

Definitions

The following electrical terms and principles will help you to understand the operation of an electric arc welder.

Welding Current: when an electrical current moves through a wire, heat is generated by the resistance of the wire to the flow of electricity. The heat generated for welding comes from an arc, which develops when electricity jumps across an air gap between the welding electrode (wire) and the workpiece. The air gap produces a high resistance, which generates arc heat of between 5972°F - 9932°F (3318°C and 5518°C).

Alternating Current (AC): an electrical current having alternating positive and negative values. In the first half cycle, the current flows in one direction, and then changes direction and flows the opposite way. In North America, alternating current is established at 60 cycles per second.

Direct Current (DC): electrical current, which flows in one direction only.

Electric Circuit: the path taken by an electric current.

Ampere (Amp or Amperage): refers to the amount of current that flows in a circuit. Amperage also allows one to measure the quality of the heat produced for welding.

Volt: the force that causes current to flow in a circuit. As a pump provides the pressure to make water flow through a water system, the welding machine produces the force that pushes the current through the wires of an electrical circuit. Voltage does not flow; only current flows.

Voltage Drop: just as water pressure drops as distance increases from the pump, so voltage drops as distance increases from the welding machine. If the welding cable gauge is too light or if the cable is too long, the welding machine is unable to supply enough electric current for welding.

Polarity: A car battery has positive and negative terminals. Welding machines also have positive (+) and negative (-) terminals or poles. Electricity always flows from the negative to the positive pole. The relationship between the negative and positive poles is called "polarity." Polarity indicates the direction of the current, and is an important factor in DC welding applications. When the electrode receives its current from the negative pole of the welding machine, and the work is connected to the positive pole, the circuit is called "straight polarity".

The direct current flows from the negative terminal through the electrode cable, electrode, workpiece, ground cable and back to the positive terminal of the machine.

Since electricity flows from the negative to the positive poles, the molten puddle in the workpiece is much hotter than the electrode tip when set up in straight polarity. As a result, straight polarity is more suitable for welding thicker materials.

When the electrode cable is connected to the positive terminal and the ground cable is connected to the negative terminal of the machine, you are set up in reverse polarity.

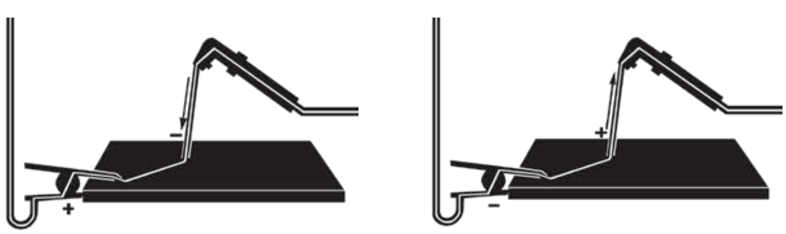


Figure 6.1

It should be noted that most welding work, except for metal inert gas (MIG) or tungsten inert gas (TIG) welding, is performed with reversed polarity rather than with straight polarity. Applications for straight polarity are limited. With reversed polarity (DCEP) and direct current (DCEN), a considerable amount of energy or heat is produced by the electrode (positive pole), while the workpiece (negative pole) receives relatively little heat.

Certain factors can affect this energy, such as the type of electrical current, the polarity, and the type of coating on the electrode. These elements influence the speed of fusion of all coated electrodes.

When the electrode is positive (anode) and the workpieces are negative (cathode), the electrons flow from the workpiece to the electrode, and the positive ions flow from the electrode to the workpiece. This results in a considerable amount of heat being given off. The amount of heat generated between the anode and the cathode can influence the way certain arcs are used.

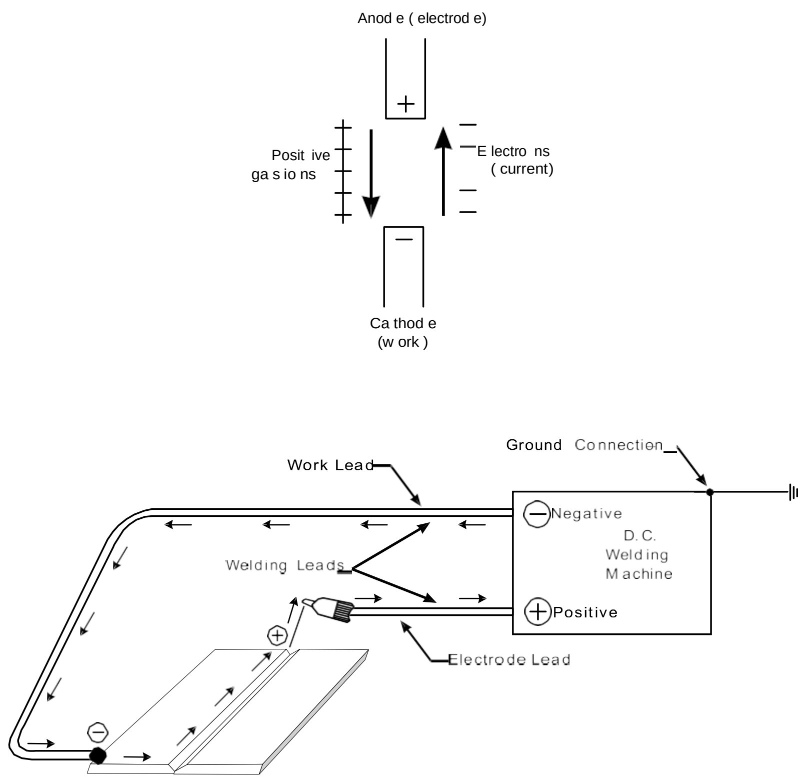


Figure 6.2

With reversed polarity, maximum penetration is achieved for any given welding conditions. The depth of penetration is linked primarily to the intensity of the current. An electrode used with reverse polarity, however, allows deeper penetration than an electrode used with straight polarity or alternating current. This is why reversed polarity is used for root passes (with backing) or for welding in a non-standard position, and reversed polarity is particularly useful for welding thin pieces of metal.

Current constantly changes direction in AC welding machines. Polarity, therefore, is of no consequence.

Worthy of note at this point is the fact that many welding electrodes may be applied by either AC or DC welding methods. Always check the label on the box before opening it.

Types of welding power sources

Electric power for arc welding is obtained in two ways:

1. it is generated at the point of use, by a generator powered by a gasoline or diesel motor, or
2. it is converted from utility line power.

There are two variations of power conversion:

a) The transformer which converts high line voltage and low amperage to the low voltage and high amperage required for AC arc welding, and

b) a similar configuration to (a) above in that a transformer is included. The current then passes through a rectifier, which changes the alternating current to direct current for DC arc welding.

A general classification of welding machines is illustrated below, but they are basically designated as generators, transformers, or rectifiers.

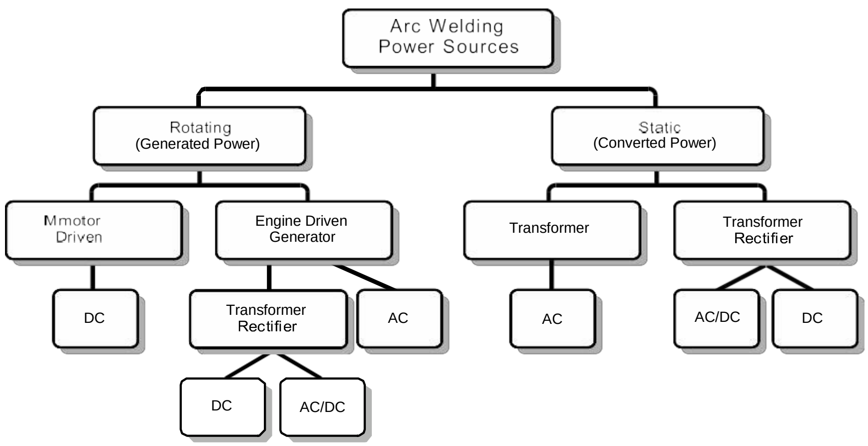


Figure 6.3

The first type of welding machines is self-contained and generally used as portable equipment where outside power lines are not available. The second type use electricity from the local power system. The latter are the ones used most often in our shops, and there are severaltypes.

Tips for wire feedwelding

There are four different feeder types In addition to the OXO wire feeder, there are wire feeders from ESAB, Hobart/Lincoln, and Miller.

The main difference between these units is that the OXO wire feeder is the only top loader and the only one developed specifically for the railroad. .

The wire size standard is 5/64. However there is a substantial amount of 1/16 wire still available and it is important to understand that each wire size requires it's own set of drive rolls.

When you are changing spools ensure that you have the correct drive roll for the wire

size. Also, be aware that you must match wire type to the job you are doing.

Lay out your equipment with an eye to minimizing any tripping hazard.

It is a best practice to install and remove the wire spool after each use. This not only protects the wire and spool from damage but it's also a lot easier on your back! A new wire spool alone, weighs 30 lbs. Together, the unit and spool weigh a total of 67 lbs.

To mount the spool remove the retaining ring and align the small hub pin with the corresponding hole in the spool.

Clip any kinks from the wire and mount the spool onto the hub.

Open the pressure assembly by flipping up the adjustment knob, and carefully thread the wire through the wire guides until two or three inches protrudes from the machine.

Flip down the adjustment knob and mount the dry filter pad. Secure the spool with the retaining ring.

Carefully insert the protruding wire into the gun or whip and then twist lock it to the wire feeder.

Plug in the gun trigger cable, … insert the ground plug, … and attach the other end to your ground clamp.

Fire up your power source, connect the power cable, … and turn on the unit.

Wire installation, is made easier by laying out the gun or whip in as straight a line as possible.

Transcript from a "Wire Feed Welding" video - Trouble Shooting Tips with Doyne Gregory – (Track WeldIndustries)

Here are some trouble shooting tips for the OXO feeder, that was designed to be out on the system.

- Before getting started, a pad does clean the wire well, but do not put oil on it because it creates other problems.

- Since there are 5/64th drive rolls in use a there is 1/16th still available if necessary tochange the 5/64th drive roll out to accompany the 1/16th – break the nut loose, pull the brass retainer off, and the drive roll will come right off. Put the 1/16th on there and you are good to go.

  - If you have the spool on and you take it off, put it back in the bag with the dust kit and back in the box. If we have to leave it back on here, take the nut and squeeze it down to lock the spool down so that we don't have another problem.

Troubleshooting

- To start trouble shooting this unit, begin with the fuses. There is a 10 amp fuse, which is the case itself and a 15 amp fuse for the gun outside the case. Eliminating one or the other is a good place to start.

  - To check one of these fuses, you depress it, turn it a quarter turn, take it out and visually check it.
  - If we have no blown fuses, then we will have to check somewhereelse.

- Turn over the unit itself. Take out the three screws on the bottom. Lift it up.
  - By just visualizing this, first thing I'd probably see is a connector, which does nothing; it doesn't go to anything; it's just a naked wire.
  - What we do then, is start from the back. First, check the relay, because everything goes through it. To check the relay, take the little strap off of it and wiggle it just briefly. Pull it out. If it's not discolored, check the three contactors.
  - If everything is good there, put it back in and secure it. It will only go back in one way.
- From there, go to the board itself. If we see discoloration in the board, we know we possibly got a problem there.
  - To take this board off, we have four screws we must loosen. Disconnect the wires.
- From there, we'd go down to our contactor, which moves this. If these are loose, it creates a problem also. So we take them off, squeeze them and put them back on.
- The only other thing that we would see on this thing is where our ground clamp goes in –which is very crucial. You have a little wire there, if it's bent too far – bend it back, put it there.
- The only other thing on this unit here, is the toggle switch. We leave it alone. If you happen to switch it, all it does is immediately stop this motor or let it free flow just briefly.
- Now, if you have the 15 amp problem – which is the gun, some of the main problems are – a restriction in the liner. The restriction in the liner could be caused by several different things in 1/16th. We could have it burnt or just flat wore out.
- To change a liner, pull that out, or to check it. Pull it out just like this, which is very user friendly. There are no Allen screws on it. If you had guns with Allen screws in the past, when they go in the ballast, you don't find them anymore. Pull this thing out. Visually check – here's where one of our problems would be, would be right through here. The other problem, is usually, right through here. We have no apparent problem, we put it back in. When you put this liner in or you change any type of liner – you put it in very slowly and gradually, because if we create a restriction or get to the goose neck – if we're grabbing it way back here, put it in – next thing you know it gets restricted – we bend it like this and we automatically ruin our brand new liner.
- Either at the end of every spool or at the end of the week, take an air nozzle to clean out the liner. To do that, grab it, put it right here at the end and just squeeze it – and blow it out.
- Basically, that is how simple this unit is for us to trouble shoot.
- Couple of things to keep in mind when using the Lincoln LN25 Hobart wire feeder or the ESAB Mobilmaster wire feeder, is when you are using the 1/16th wire, it is very critical that you keep your whip straight at all times. When you are finished at the end of the week, make sure that you blow out your liner.
- Another thing, when you are using the ESAB Mobilmaster wire feed, if you are loosing power to the gun – you can take your whip, and look at the contacts. If you look inside the contact, one of the contacts may be shoved in too far so it loses contact with the whip.

Transformers

The AC transformer type welding machine is usually the lightest and least expensive. Itsmain advantages are low operating and maintenance costs and near noiseless operation.

High voltage, low amperage alternating current from outside power lines is converted by a transformer to low voltage, high amperage alternating current.

In welding machines using AC current, the direction of current flow reverses itself 60 times per second from the negative to the positive poles and vice-versa. Therefore, there is no straight or reverse polarity and the cable connections to the positive and negative terminals do not have to be adjusted.

In AC welding, 50% of the heat produced is released in the electrode and 50% is released in the workpiece.

The current supplied by outside power lines is high voltage, low amperage alternating current. In order to weld, however, this current must be converted by the welding machine to low voltage, high amperage current. While a low voltage level is needed to control the arc, a high amperage level is required to produce enough heat for welding.

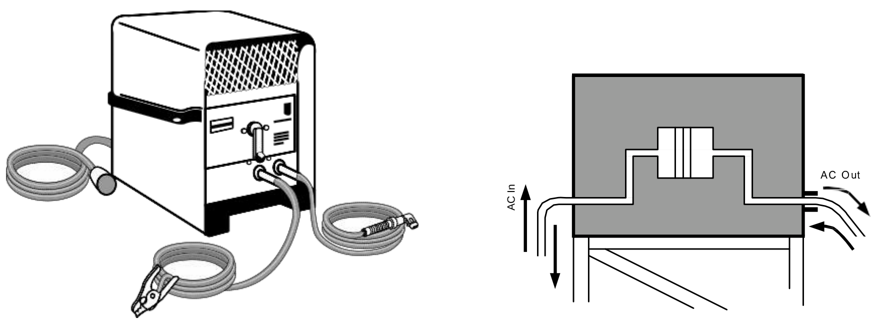


Figure 6.4 - AC welding machine

Generators

The engine driven (gasoline or diesel) DC generator is often supplied to railway welders . These machines are able to handle all track welding electrodes of various sizes, in either polarity, as recommended by the electrode manufacturer.

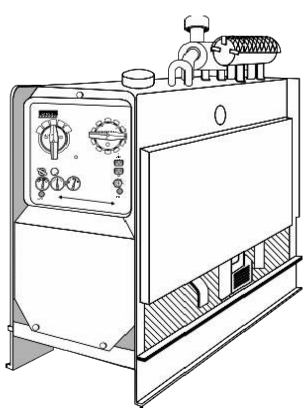


Figure6.5

Figure6.6

Rectifiers

These machines are the most versatile welders available. They may have multiple functions and some models can produce AC as well as DC welding current at whatever amperage is required. They are also capable of generating power for other equipment such as high frequency grinding equipment.

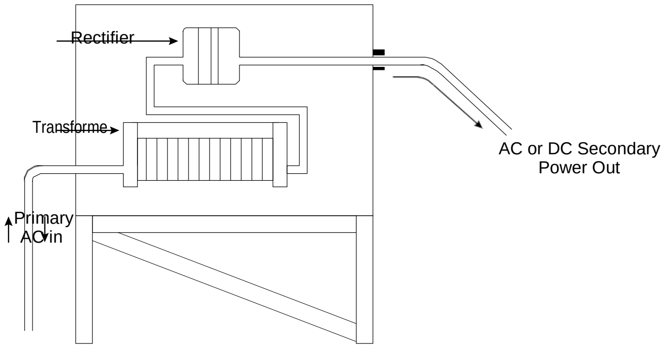


Figure 6.7- AC/DCweldingmachine - ACdriven(rectifier)

Power capacity

All welding machines have a maximum current output rating identified in amperes on the faceplate of the machine. While the maximum output may be as high as 1200 amps, most welders range from 250 to 600 amps. The operating capacity of the welding machine is a determining factor when assigning equipment according to the work to be done.

Most generators are equipped with two standard 120 volt AC power outlets to allow for the operation of electric grinders, lights, etc.

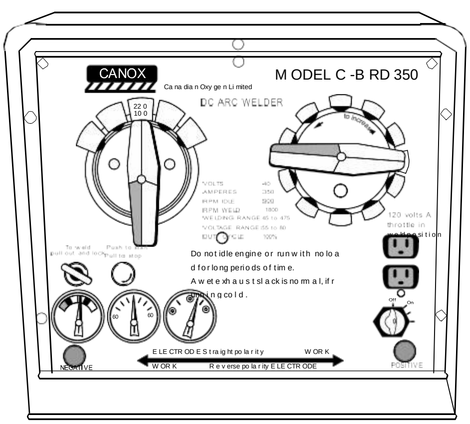


Figure6.8-Typicalcontrolpanel

Figure 6.9 - Millercontrol panel

Duty cycle

Duty cycle is expressed in percentage and is stated on the faceplate. Duty cycle is the length of time that a welding machine can be operated continually at its total rated output in any ten minute period. Example: a welding machine rated 400 amps at 60% duty cycle means it can be operated safely at a full 400 amps welding setting for 6 out of every 10 minutes. It must idle and cool for the remaining 4 minutes.

While duty cycles range from 20% to 100%, the most common duty cycle is 60%.

If you go over the maximum duty cycle, most machines will shut off automatically to protect them from overloading and overheating. Once this happens, the welding machine cannot be restarted until it has cooled down.

To avoid overloading and shut-downs, choose a machine that has a high duty cycle and more maximum output amperage than you need for your job.

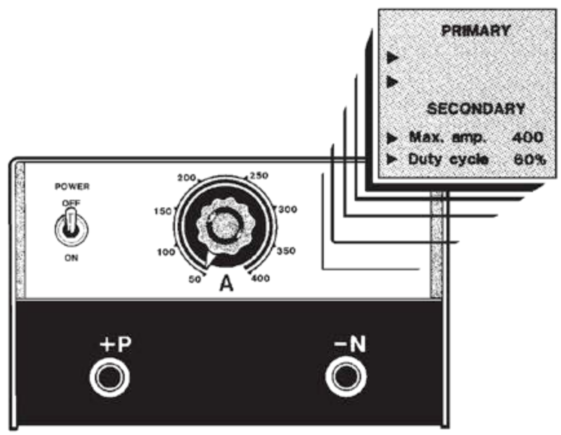


Figure 6.10 -Duty cycle

Panel controls

Welding machines are produced by many different manufacturers. They may have different switches, dial adjustments or extra features but the functions of the basic controls are the same.

Welding current on some AC transformer machines is adjusted by plugging the welding cable leads into taps on the front panel. Each tap supplies a specific current value.

Transformers, rectifiers, and electric motor generators are started by the simple throw of an ON/ OFF power switch. Engine driven generators are started by turning or pushing an ignition switch, which starts the internal combustion engine thereby driving the electric generator.

Most DC welding machines have a polarity switch built in, eliminating the need to uncouple and exchange the cable leads when selecting straight or reverse polarity.

The more modern machines are equipped with two current adjusters – the main switch is used to select a range, either “high” or “low” or a variety of ranges, the other control is used to set a specific measurement or percentage of the chosen range. The maximum output needed on a machine depends on the amperage required for the job. In turn, the amperage required depends on the size of the electrode – the larger the diameter of the electrode, the higher thesetting.

The amperage range of the electrodes is written on the box. In the example in theillustration belo w, the amperage range is 90 - 135 amps. You can then take the mid-point of the range to arrive at the approximate amperage setting, which would be 110 amps.

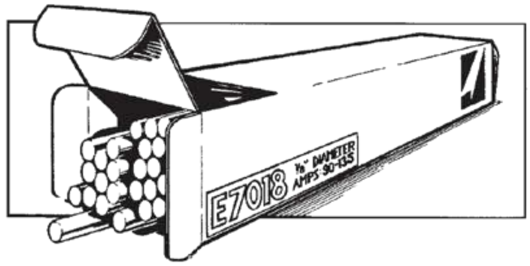


Figure6.11-Labelonboxof electrodes

If the amperage range is not indicated on the box, the diameter of the electrode will be indicated in inches. In this case, you can use the following formula to determine the amperage setting.

Example:

If the diameter of the electrode is 1/4”, convert it to a decimal figure with three digits. 1/4” changed to a decimal = 1 ÷ 4 = .250.
Drop the decimal point and you have the approximate amperage setting, i.e. 250 amps. If you don’t know the electrode diameter because the box is not available, you can determine the diameter of the electrode by measuring it.

Caution:

Never operate a range switch or a polarity switch while a welding arc is established. Arcing caused by opening a switch carrying high current will burn the contact surfaces of the switch decreasing its current carrying capacity or destroying it completely.

Note:

All welders must be qualified in the operation of the machine assigned to them. You must be aware of minor troubleshooting remedies but leave the mechanical problems to the mechanics.

Arc welding accessories

For maximum safety and efficiency, listed below are GO Transit approved arc-welding accessories, other types and or models will require written acceptance from the GO Transit Senior Manager of Track and Structures.

Automatic wire feedmachines

Direct current, arc-welding machines are adaptable to variable voltage wire feeders.

1. 120 Volt AC Power Line
2. Welding Machine
3. Wire Spool
4. Wire Feeder
5. Welding Gun
6. Workplace

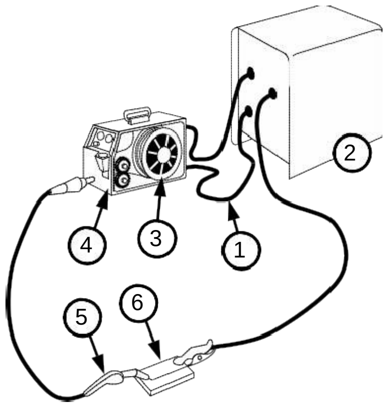
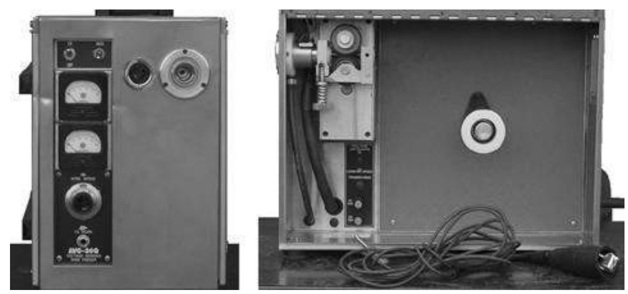
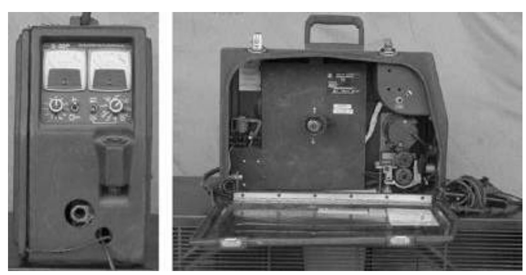


Figure 6.12

Lincoln type



OXO type



Miller type

Figure 6.13 Automatic wire feeders

In this application, the standard type electrode is replaced by a continuous spool of wire, which is fed to the work by special feed rollers controlled by a variable speed motor. The hand-held gun assembly is controlled by the operator making the weld.

Note:

Operation of arc welding power sources in signal territory will be covered in Chapter 10. This material will be taught to workers required to work on signal tracks.

Air compressors

Air compressors to meet the needs for air-carbon-arc cutting and gouging are available. These compressors can be built into the welding machine and receive their power from the same motor which drives the generator or may be powered by a separate unit. Air compressors may also be positioned under the hood of a truck.

Special electrodes, electrode holders, and cables are required for air-carbon-arc gouging.

Welding cables and connections

Cables of the correct diameter as specified below must be used. If the cable is too small, it will overload and power will be lost. Furthermore, larger cables are necessary to carry the required current voltage long distances from the machine.

Use the table as a guide to select the correct cable size for the anticipated maximum weld current, which will be used. Total cable length must be calculated.

Example:

75’ electrode cable, 25’ ground cable – select the cable size recommended for 100’ and the maximum weld current to be used.

Welding Amperes	Total Length of Cable (Copper) in Weld Circuit							
	50	100	150	200	250	300	350	400
100	4	4	2	2	2	1	1/0	1/0
150	2	2	2	1	1/0	2/0	3/0	3/0
200	1	1	1	1/0	2/0	3/0	4/0	4/0
250	1/0	1/0	1/0	2/0	3/0	4/0	4/0	2-2/0
300	2/0	2/0	2/0	3/0	4/0	4/0	2-2/0	2-3/0
350	3/0	3/0	3/0	4/0	4/0	2-2/0	2-3/0	2-3/0
400	3/0	3/0	3/0	4/0	2-2/0	2-3/0	3-2/0	2-4/0

Conversion			
Feet	Metres	Feet	Metres
25'	7.62	250'	76.20
75'	22.86	300'	91.44
100'	30.48	350'	106.68
150'	45.72	400'	121.92
200'	60.96		

Figure 6.14 - Cable size table

All connectors must be properly attached to the leads and must be well maintained to avoid excessive voltage drop. Loose connections may even produce arcing at the connection. Connections must be fully insulated. An easy way to check for damaged cables and points where power is wasted is by checking for hot spots by feel. Any cable connection must have the female connector connected towards the welding machine. Color code your cables to identify positive and negative cables

Electrode holder

The holder should be light, well insulated, and sturdy enough to carry the welding machines’ maximum current. Only GO Transit approved, fully insulated holders (short stub) are allowed. When the track must be cleared to let a train pass, remove the electrode from the holder to prevent accidental arcing with any track component.

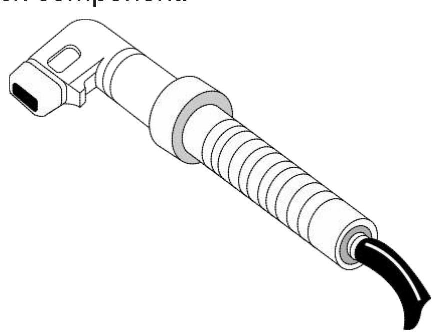


Figure 6.15 - Electrode holder (short type)

The electrode holder must be kept clean and filed if necessary, where the jaws grip the electrode. An electrode holder must never be cooled by immersion in water.

Ground clamps

These may be a “C” type clamp, a spring type “snap on” clamp, or a magnetic ground connector. Contact faces of the ground clamp must be kept clean. The ground clamp must be securely fastened to the cable, and must make secure electrical contact with the material being welded. The surface must be cleaned by grinding or wire brushing and then, it must be attached on the same rail and as near the welding location as possible. When welding on machinery with moving parts, clamps should never be attached where the current may flash across the parts causing arc burn and damage. Of course, the machinery must be shut down when welding is in progress.

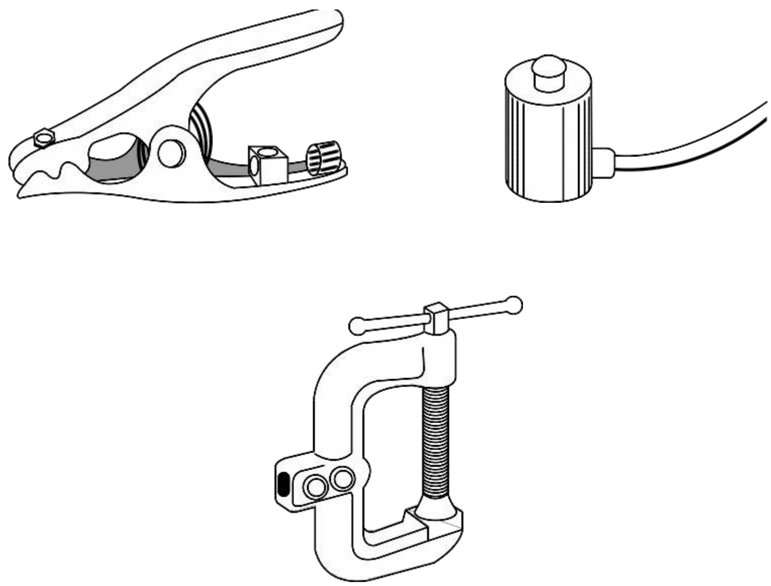


Figure 6.16

Accurate current control is very important. The “C” clamp ground connection will exert tremendous pressure on the work, therefore reducing current loss to a minimum. The clamping bolt is made from steel to prevent damage from spatter. The cable connection will take 4/0 cable.

Welding helmets and hand shields

Welding helmets and hand shields must have approved filter lenses. The filter lens shallbe protected with a plain Plexiglas spatter shield, which is easily replaced when it becomes pitted. Chipping goggles must be worn if the helmet does not have a flip front with armor plate lens or if a hand shield is used.

Lenses bear a permanent distinctive marking, by which the shade number may be readily identified. Lenses with a shade number less than 10 should not be used when arcwelding.

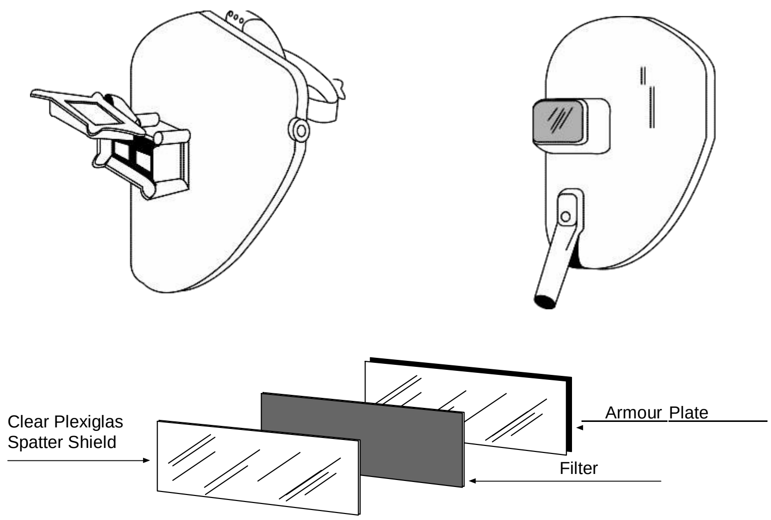


Figure 6.17 - Standard protectionlenses

Personal protective clothing and equipment

Always wear clothing that will protect the body from sparks and arc rays. Wear leather aprons and leggings where the type of job requires their use. Always wear approved welding gloves. All parts of the body must be protected from arc rays. Wear flame retardant clothing, leathers, synthetics. Do not wear polyester etc.

Chipping hammer and Needle scaler

Needle scalers and chipping hammers are used to remove slag and burned flux from the welds.

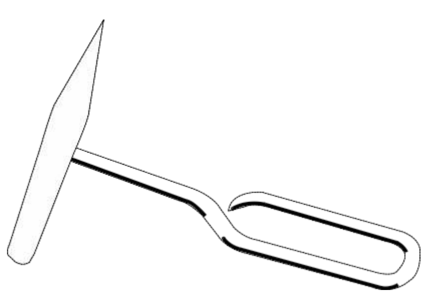


Figure 6.18-Chipping hammer

Figure 6.19 – Needlescaler

Wire brush

The wire brush is used to remove all the remaining loose flux and slag (after chipping theweld), after each weld pass! Failure to do so will result in unsatisfactory welds.

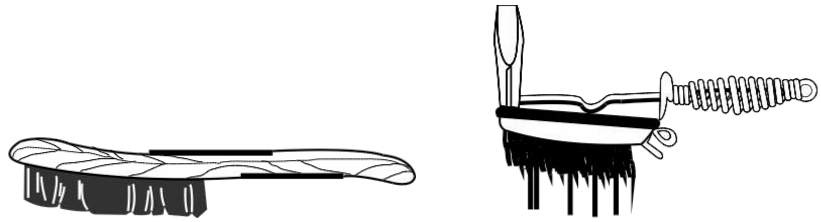


Figure 6.19

Maintenance of arc welding power sources

Preventive maintenance

To obtain maximum efficiency from an arc-welding unit, a structured maintenance program should be set up and followed.

Welding machines and power sources must be blown out periodically with compressed air at low pressure, not exceeding 207 KPA (30 lbs.), in order to remove dirt and dust. Where welding machines and power sources are used continuously in shop operations, regular maintenance by electricians (at least once a year) should be scheduled to reduce the chance of “burn out” due to electrically conductive dust contaminating the units.

Always wipe off spilled oil and check the fan belt for tension and alignment in engine- driven welding machines. The battery should be checked for water regularly. Add distilled water as required.

1. Air cleaners

Service the air cleaner as often as demanded by the operating conditions. Follow manufacturer’s recommendations.

2. Fuel systems

Use clean fuel and keep the fuel tank full. When filling the fuel tank, use a railway approved fuel can, grounding clamps and cables, and a funnel with a fine screen. Never fill the fuel tank when the engine is running or is hot. In winter, add methyl hydrate to the fuel. Never put gasoline in a diesel driven engine, or diesel fuel in gasoline driven engines; the results are disastrous! Drain the sediment bowl (as impurities or water collects) and replace the gasket and screen when reassembling.

Note:

Diesel driven engines have primary and secondary fuel filters. These filters must be changed out regularly as recommended by the manufacturer. Drain about a cup full of fuel from the primary filter at the end of every workday.

3. Crankcase oil

Check oil level before starting each day’s work. Add oil if level reaches the “add oil” mark. Do not overfill. Use oil as recommended by manufacturer, summer or winter grades. Change the oil filter regularly as instructed.

4. Spark plugs (gasoline engine)

Clean the depression in the engine block around plugs before removing them. Remove the plug s using a spark plug wrench. Clean and reset the electrode to manufacturer's specifications. Reinstall plugs. Be sure the plug wires are firmly in place.

5. Radiator

To avoid scalding, do not remove radiator pressure cap when the engine is hot. Maintain level with water and anti-freeze.

6. Caution

Do not exceed tilt angles or engine could be damaged.

- 20° side to side
- 30° front to back

Remember:

Don't take chances with electricity.

Electricity can travel through the human body just like through wire, but the results are disastrous!

It is the welder's responsibility to maintain the machine to the manufacturer's specifications.

7. Governor control

Clean and lubricate all governor linkage to ensure free operation. Free up any joints that may be binding or rods and levers that may have twisted, check full throttle.

If you are involved in a seasonal work operation, be sure to affix a tag to your machines indicating exactly what problems were encountered, and indicate exactly what type of repairs are required. Do this before shipping them at the close of the season. Follow up with a memo, in writing, to your supervisor. Failure to observe this procedure can result in receipt of a defective machine at the start of the work season next year.

Good care and maintenance usually results in reliable equipment.

Chapter7: Electrodes- Basic

Introduction

This chapter deals with the types of electrodes and spool wire used most at GO Transit. Electrodes are coated metal wires which carry the electrical current and which have approximately the same mechanical properties when deposited as the metal being welded. Electrodes come in various diameters, lengths, and colors, according to the application. Electrodes are designed for DC or AC welding machines (or both) and their usage depends on the welding position. Positive or negative indications on electrodes indicate polarity. Some are best suited for flat position only, others flat and horizontal, and some types are used for welding in any position.

Thus there are different types and categories of electrodes:

Types

A) DC electrodes

B) Electrodes for both AC and DC

Categories

Electrodes and spool wire are classified according to the type of metal to be welded. There are electrodes and spool wire for:

A) Non-ferrous metals and alloys

B) Cast iron

C) Regular steel

D) Special types of steel (alloys)

The diameter of an electrode is determined by the core and expressed in millimetres or inches. There are various factors, which can influence the choice of an electrode:

1. The type of welding machine
2. The position, type, and desired quality of the joint
3. The thickness of the metal plates to be welded
4. Price

The coating and the core wire determine the operating characteristics, and the addition of alloy in both coating and wire make the difference in the physical properties of the deposited metal.

Note on continuouselectrodes:

Electrodes in the form of wire wound on spools are used on continuous feed welding machines. The wire may be solid, in which case a gas must be supplied to protect the weld metal, or it may have fluxing and alloying elements within the wire. The latter type is known as “flux-cored”. Continuous electrodes will be discussed in another chapter.

Types of electrode coatings

There are three types of electrode coatings:

1. Cellulose
2. Rutile
3. Basic

A) Cellulose

More than 30% of the weight of this type of coating is made up of cellulose. The core of this type of electrode is steel and contains:

- 0.10 to 0.14% carbon
- 0.40 to 0.60% manganese
- 0.025% siliceous (maximum)

This type of coating is recommended for vertical and overhead welding.

B) Rutile

This type of coating consists essentially of rutile, a titanium oxide, and certain silicon based materials such as feldspar and clay. The coating also contains a deoxidizer, ferro-manganese, and a mixture of sodium silicate which acts as a binder. This coating is suitable for filling holes, welding grooves in the horizontal position, and welding poorly positioned plates.

C) Basic

This type of electrode coating has a controlled low amount of diffusible hydrogen. It is made of calcium hydrate, fluorine, sodium carbonate, spath, and ferrous alloys as deoxidizers. Manufacturers heat these electrodes to remove humidity as much as possible.

Today most electrodes contain a powdered iron coating, which allows the welder to work more quickly. Once the arc is struck, the metal begins to melt and the powdered iron mixes with the metal. A larger amount of metal is thus deposited (core + powdered iron).

Role of the coating

Each of the substances in the flux is intended to serve a particular function in the welding process:

1. Some act as cleansing and deoxidizing agents in the molten puddle.
2. Others ensure capillary action in the slag and a viscous consistency, which holds the drops of molten metal in place.
3. Some vaporize to protect the weld metal from the atmosphere. Without these chemicals, oxygen and nitrogen would be absorbed from the surrounding air and oxides or nitrides would form within the metal’s grain structure. Oxide greatly weakens the weld metal and reduces impact strength. Nitrogen mixes with the iron producing nitrides, which make the weld extremely brittle.
4. Other substances form a slag over the weld metal, which further protects it until it has cooled sufficiently to no longer be affected by atmospheric contamination.
5. Some provide easier arc starting, stabilize the arc, and reduce spatter, and others permit better penetration.

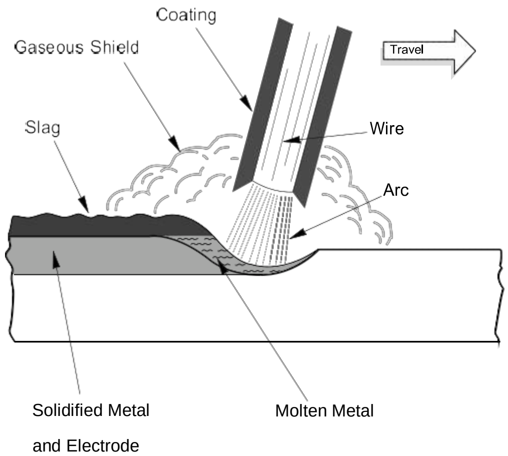


Figure 7.1

Finally, electrode boxes or packages must indicate the following information:

1. The legal name and address of the manufacturer
2. The commercial name of the company
3. The lot number
4. The weight of the contents expressed in kilos or pounds
5. The core diameter
6. The type of current that can be used - AC, DC, or both
7. Polarity (minimum voltage required to strike an arc)
8. Average amperage (flat position, with a 20% margin)
9. The symbol indicating that the electrodes conform with CSA standards (Canadian Standards Association)

Identification

The CSA and the American Welding Society (AWS) both use a classification system based on four factors:

1. Minimal tensile strength
2. Type of coating
3. Welding positions allowed
4. Type of current to use

For identification purposes, each class of electrode is identified by one or more letters, followed by a three, four, or five digit number. Some electrodes also have a color dot painted on or near the uncoated end, but at GO Transit only the classification number is used to identify the electrode.

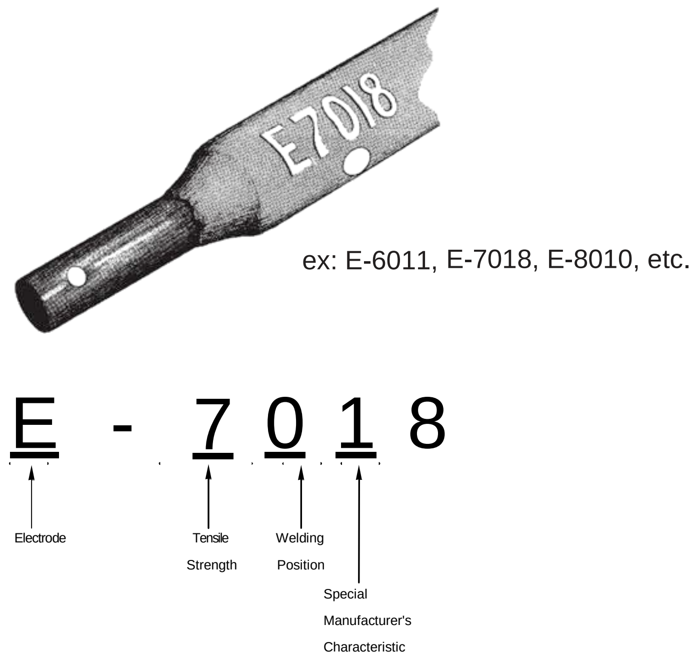


Figure 7.2

Let’s take a closer look at the four digit classification system.

The prefix “E” identifies it as an electrode.

The first two digits of the four digit number and the first three of a five digit number multiplied by 1,000 indicate tensile strength, i.e. the maximum amount of force the metal can withstand before permanent damage occurs. The amount of force is generally measured in pounds per square inch (psi), but also sometimes in mega-pascals (MPa).

E-60XX – tensile strength 60,000 psi

E-70XX – tensile strength 70,000 psi

E-100XX – tensile strength 100,000 psi

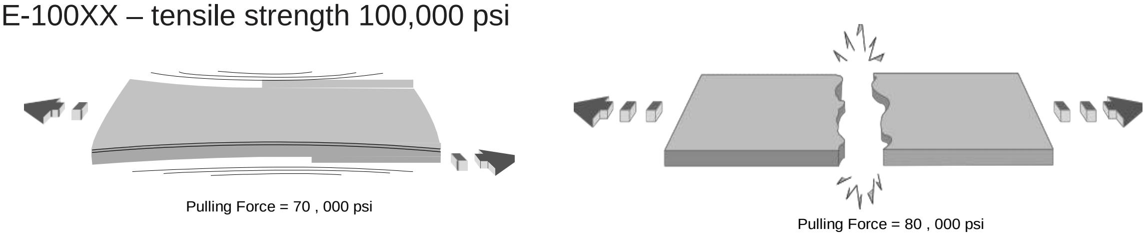


Figure 7.3

The third digit indicates position.

E-XX1X – all positions

E- X2X – horizontal or flat

E-XX3X – flat position only

The fourth digit indicates a special characteristic of the electrode such as type of coating, weld quality, type of arc, or amount of penetration. Their meanings are as follows:

Fourth Digit Electrode Characteristics

Fourth Digit	Coating	Weld Current	Weld Characteristics
0	Cellulose sodium	DCR	Deep penetration, flat or concave beads, fast-fill
1	Cellulose potassium	AC, DCR	Deep penetration, flat or concave beads, fast-fill
2	Titana sodium	AC, DCS	Medium penetration, convex beads, full freeze
3	Titana potassium	AC, DCR, DCS	Shallow penetration, convex beads, full freeze
4	Titana iron powder	AC, DCR, DCS	Medium penetration, fast deposit, full freeze fast freeze
5	Low-hydrogen sodium	DCR	Moderate penetration, convex beads, welding high-sulfur, high-carbon steels
6	Low-hydrogen potassium	AC, DCR DCS	Moderate penetration, convex beads, welding high-sulfur, high-carbon steels
7	Iron powder iron oxide	AC, DCR DCS	Medium penetration, flat beads, fast-freeze
8	Iron Powder Low-Hydrogen	AC, DCR	Shallow to medium penetration, convex beads, full freeze

AC = Alternate Current DCR = Reversed Polarity
DC = Direct Current DCS = Straight Polarity

Figure 7.4

In the five digit system, the first three digits indicate tensile strength expressed in pounds per square inch or mega-pascals, the fourth digit indicates the welding position, and the fifth indicates the type of current to use and the type of coating. For proper identification, the last two numbers should sometimes be read together.

Know Your Arc Welding Electrodes

CSA Class	Current & Polarity Polarity	Welding Position	Type of Covering	Type of Arc	Penetration	Surface Appearance	Type of Slag	Slag
EXXX10	DC, reverse polarity (electrode positive)	All	high cellulose sodium	digging	deep	flat, wavy	organic	thin
EXXX11	AC or DC reverse polarity	All	high cellulose potassium	digging	deep	flat, wavy	organic	thin
EXXX12	DC straight polarity	All	high titanium sodium	medium	medium	rutile		heavy
EXXX13	AC or DC straight	All	high titanium sodium	soft	shallow	flat or concave, slight ripple	rutile	medium
EXXX14	DC either polarity or AC	All	iron powder, titanium	soft	medium	flat, slightly convex, smooth, ripple	rutile removed	easily
EXXX15	DC reverse polarity	All	low hydrogen sodium	medium	medium	flat, wavy	low hydrogen	medium
EXXX16	AC or DC reverse polarity	All	low hydrogen potassium	medium	medium	flat, wavy	low hydrogen	medium
EXXX18	AC or DC reverse polarity	All	iron powder, low hydrogen	medium	shallow	flat, smooth, fine ripple	low hydrogen	medium
EXXX24	DC either polarity or AC	H. fillets and flat	iron powder, titanium		shallow	slightly convex, very smooth, fineripple	rutile	heavy
EXXX27	DC straight polarity or AC for fillets, DC either polarity or AC for flat	H. fillets and flat	iron powder, iron oxide	soft	medium	flat to slightly concave, smooth fine ripple	mineral	heavy
EXXX28	AC or DC reverse polarity	H. fillets and flat	iron powder, low hydrogen	medium	shallow	flat, smooth, fine ripple	low hydrogen	medium

Pocket Guide LIQUID CARBONIC

Figure 7.5

How to select an electrode

Choosing an electrode involves deciding on the right type and diameter of electrode for the job you are doing. The first step is to decide on the type of electrode you will need. The decision table shown in Figure 7-6 has been designed to help you make the right choice and is based on the electrodes used most at GO Transit. There are seven factors to keep in mind.

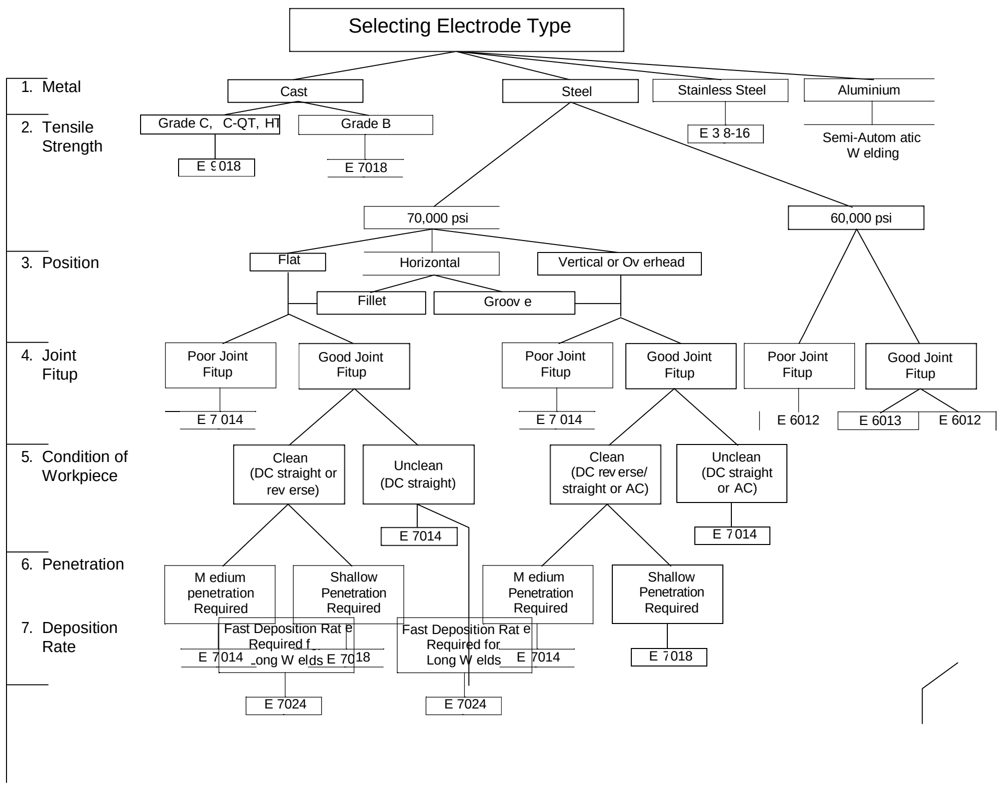


Figure 7.6

1. *Metal to be welded*

The first thing you will have to do is to identify the metal on which you are welding. The metals used most frequently at GO Transit are cast steel, carbon steel, aluminum, and stainless steel. The following section will help you to identify these metals.

Cast steel

Products produced by pouring into molds are referred to as cast. In the track department austenitic manganese frogs, SGM's, sliding joints are all cast products. Austenetic steel can be easily identified by placing a magnet on the component. When it is removed, there is virtually no magnetic pull.

Aluminum

Aluminum can be identified by its dull, silvery color and its light weight. At GO Transit, it is most often welded using the protective gas metal arc process.

Stainless steel

Stainless steel can be identified by its rust-free, bright, and highly polished surface. As the decision table indicates, once you have identified the metal as stainless steel, you can pinpoint the electrode you will need: an E308-16.

Carbon steel

Carbon steel can be identified by its gray-blue color, the light gray color that appears on its edges, and the rusty scale that sometimes appears on its surface.

2. Tensile strength

If you have identified the metal you are welding on as either cast steel or carbon steel, the next step is to pinpoint the tensile strength you will need. As you may remember, the tensile strength of the electrode must match the tensile strength of the metal you are welding.

Carbon steel

The tensile strength of carbon steel depends on the amount of carbon in the steel. The higher the carbon content, the higher the tensile strength of the steel and the harder and more brittle it is. There are two ways to determine the tensile strength of carbon steel: a) by determining thestress carried by the car part, and b) by conducting a spark test.

A) Ensure that the grinding wheel will produce the right effect. Some grinding wheels aresofter than others.

B) Four factors must be taken into consideration:

1 - the length of the spark

2 - the shape of the sparks

3 - the number of sparks

4 - the color of the spark, etc.

3. *Penetration*

As indicated in Figure 7-7, if the electrode diameter is held constant, the amount of penetration you get depends on the type of electrode used. Almost all electrodes used at GO Transit have medium penetration, but there are other electrodes, which provide deep penetration.

4. *Deposition rate*

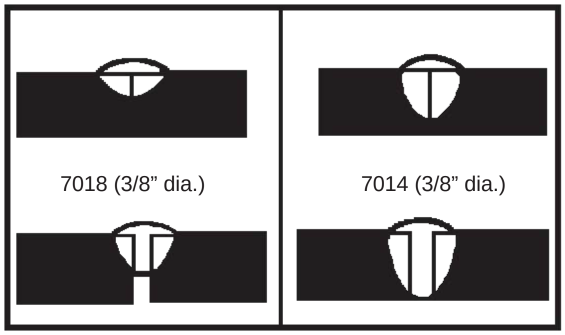


Figure 7.7

Where a choice between electrodes still remains, there is another factor to take into consideration - the deposition rate (the rate at which the electrode deposits filler metal on the weld). The E7024 is best suited for long welds since it has a fast deposition rate and will produce a very smooth weld bead. This is because the E7024 has a thick coating that does not burn as quickly as the core wire, so the electrode can be dragged over the workpiece surface and the correct arc length can easily be maintained.

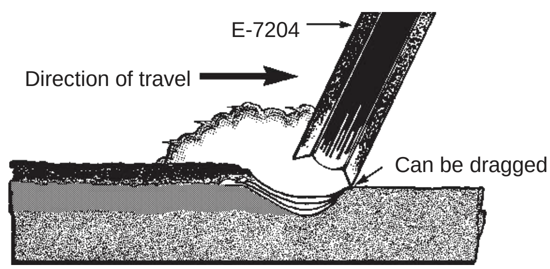


Figure 7.8

5. *Positions*

All electrodes are designed for use in one or more positions. If you turn back to the table (Figure 7-5), you will notice under the heading "Welding Position" the characteristics that must be taken into consideration in choosing the appropriate electrode.

6. *Joint fit-up*

Joint fit-up is another important thing to take into consideration when choosing an electrode. The space between two plates can be too wide or too narrow. Suppose a large crack needs to be repaired. An electrode, which ensures fast solidification, would be used for the first weld bead or root pass. For subsequent beads, another type of electrode could be used.

When the plates of a joint are well positioned, a greater selection of electrodes is available because solidification speed is not highly important. A final factor must be taken into consideration when selecting an electrode - condition of the workpiece.

7. Condition of the workpiece

Before welding a joint that has paint or rust on its surface, you should use a wire brush to clean it. However, if the surface remains unclean, you should use an electrode that operates on DCstraight polarity. If the joint to be welded is clean, an electrode using either reverse or straight polarity may be used. The reason for this is that in straight polarity, the heat is concentrated in the workpiece, which means that the puddle remains liquid longer and impurities rise to the surface. In reverse polarity, the heat is concentrated in the electrode so the puddle solidifies faster, causing existing impurities to be trapped in the weld bead, and producing porosity.

As Figure 7-6 indicates, “Condition of workpiece,” some of the electrodes used at CN GO can be used with either DC or AC. However, these electrodes all work most efficiently with DC. Similarly, the DC electrodes listed in the table as appropriate for either straight or reverse polarity actually work best in straight polarity. So for unclean workpieces requiring straight polarity, you can use an E7014, or if you are welding in the flat position or welding a fillet weld in the horizontal position, you can also use an E7024. For clean workpieces that can use either DC straight orreverse polarity, you can use an E7014, E7018 or (where appropriate) an E7024 electrode.

Electrode diameter

Once you have selected the type of electrode you will need, you will have to decide on the right electrode diameter. To do that you must first know what size weld you will need.

The throat of the weld must be as thick, or thicker, than the thinnest piece you are welding. So if two workpieces with thicknesses of 10 mm (3/8”) and 13 mm (1/2”) are being welded, the weld must be at least10 mm (3/8”) thick. To obtain the required weld width, you can either use weave beads, or one or more straight beads (ex: for a 10mm (3/8”) thick weld, you can use one 10 mm (3/8”) bead or two 5 mm (3/16”) beads).

The size of the weld bead produced depends on (a) the electrode diameter, and (b) the amperage setting used. As Figure 7-9 indicates, each electrode diameter can be used with a range of metal widths and amperage settings. The thicker the metal, the higher the amperage required, and the higher the amperage, the larger the bead size.

Electrode Diameter ***	M etal Thickness* ***	Amperage (Flat Welding)* ***
2.5 mm (3/32")	1.5 mm (1/16") - 3 mm (1/8")	50 - 90
3 mm (1/8")	3 mm (1/8") - 6 mm (1/4")	90 - 140
4 mm (5/32")	6 mm (1/4") - 10 mm** (3/8")	120 - 180
5 mm (3/16")	10 mm (3/8") - 13 mm (1/2")	150 - 230
6 mm (1/4")	20 mm (3/4") - 25 mm (1")	200 - 300

Figure7.9-Electrodesize chart(Applicable to flat and horizontal positions)

To choose the correct electrode diameter from the size chart, you must first determine the size of the weld needed by noting the thickness of the metal you are welding. Next, you must determine the position you are welding in. Where you have a choice of two electrode diameters for a certain metal thickness:

a) in the flat and horizontal (fillet) positions, choose the larger diameter; it allows you to weld faster.

b) in the vertical, overhead, and horizontal (butt) positions, choose the smaller diameter to keep the amperage and the puddle size as small as possible so that the molten metal is less likely to run. For a metal thickness of 13 mm (1/2”), go down one size to a 4mm (5/32”) electrode. In these positions, a 6 mm (1/4”) diameter electrode cannot be used since the puddle it would produce would be too large to control. Since the molten puddle produced by an E308-16 electrode is very fluid, the largest diameter that can be used in these positions is 4 mm (5/32”).

Once you have chosen the diameter you will need, you will have to determine the amperage setting. The size chart in Figure 7-10 indicates the **amperage range** for a given electrode diameter. The precise amperage you choose within that range depends on the thickness of the metal you are welding. So with an electrode diameter of 2.5 mm (3/32”) and a metal thickness of 1.5 mm (1/16”), the amperage selected would be 50. With the same electrode diameter and a metal thickness of 3 mm (1/8”), the amperage selected would be 90.

As an exercise, try determining the correct electrode diameter and amperage required for welding a tee joint in the horizontal position with two plates, 10 mm (3/8”) and 13 mm (1/2”) thick.

Solution: the size of the weld should correspond to the thinnest piece you are welding, i.e. 10 mm (3/8”). For this metal thickness, according to the size chart, (Figure 7-10) you have a choice of either a 4 or 5 mm (5/32” and 3/16”) electrode, and since you are welding in the horizontal position, select the larger diameter: 5 mm (3/16”). The correct amperage setting is 150 amps.

In the vertical and overhead positions, the amperage used is 10% to 15% less than that used in the flat and/or horizontal positions. With a 2.5 mm (3/32”) electrode and a metal thickness of 1.5 mm (1/16”) in the overhead position, the amperage should be set at about 43 to 45 amps.

Penetration: A summary

This section brings together the material you have learned so far on penetration.

As mentioned previously, the amount of penetration required for a joint depends on:

a) the amount of stress on the joint,

b) the thickness of the it is composed of.

You have also learned that penetration is increased by:

1. adjusting the joint edges
2. preparing them (beveling) and separating them
3. or using an electrode that provides deep or average penetration.

Penetration is also increased by adding heat (i.e. raising the amperage setting). Since electrodes require higher amperage setting as the diameter increases, you will get more penetration when using an electrode with a large diameter. In the same way, you can achieve more penetration for any given electrode diameter if the amperage is raised in relation to the thickness of the material.

Loss of electrode metal

Loss of metal through arc spitting is about 8% to 18% of the weight of the electrode. Loss on the ends is 17% of the weight of the electrode to a maximum of 30mm (19/16”) total loss is between 25% and 35% of the weight of the electrode.

Care, storage, andinspection

Electrodes that are not in good condition will cause welding problems that can result in waste, extra cost, inferior welds and, in certain circumstances, hazardous conditions. Electrodes must therefore be properly stored and inspected before use. There should be no chips or cracks in the coating, which would cause interruptions in the arc and result in a poor weld. A single chipped area may be burned off on a piece of scrap metal.

Note*:*

Besides oxygen and nitrogen, another gas absorbed during welding produces disastrous effects. This gas is hydrogen. Hydrogen is not usually absorbed from the atmosphere but comes from moisture in the electrode coating. The presence of this gas in the weld metal weakens thegrain structure and is the chief cause of porosity and under-bead cracking.

If electrodes are exposed to the atmosphere for long periods, moisture will accumulate in the coating. That moisture can cause cracks in the weld or erratic arcing.

To ensure that electrodes are not exposed to the atmosphere for toolong:

1. do not take more electrodes from the storage area than you need, and
2. return unused electrodes to the proper storage area. If electrodes have been exposed tothe air for more than 10 hours they may be dried in ovens to remove existing moisture.

An economical way to build an electrode storage oven is:

1st Make an average sized (wood or steel) box 610 x 610mm (2’x2’) with a door on the front (preferably insulated).

2nd Place a 60 or 100 watt light bulb inside the box. Leave the light turned on continuously. The heat from the light bulb will help to remove any humidity.

Inspecting electrodes

Electrodes should be inspected to make sure that:

a) There are no chips in the electrode coating, which would cause interruptions in the arc and result in a poor weld.

b) The coating has the same thickness all the way around the core wire. If it has an unequal thickness, the burn-off will be uneven.

If the electrode has either of these faults, it should be discarded.

And remember:

The importance of keeping electrodes dry cannot be overstressed. They must be stored in a warm, dry place and, after opening the sealed container unused electrodes should be placed in an electrode oven or other drying container. Those that have been exposed directly to moisture (left in the rain for example) must be discarded.

The recommended size of wire for the wire feeds is 5/64. However present stocks of 1/16 are being used but should not be purchased in the future

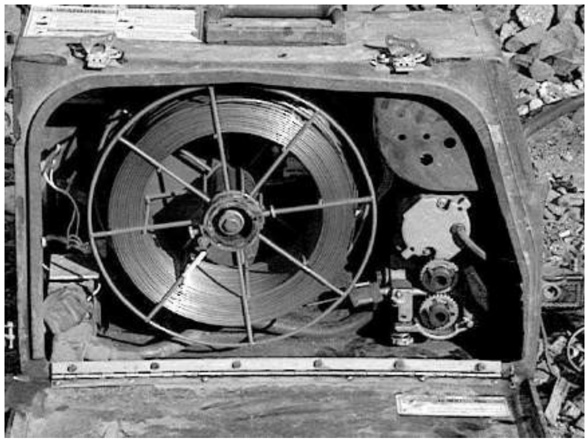


Figure 7.10 – Spool wire

Chapter 8: Distortion in Track Welding

Introduction

Even if electric arc welding is quick and easy, problems can arise which affect the quality of the weld or which make the work difficult. This chapter deals with distortion and the various defects which occur in welding. Methods and techniques are also provided to help prevent welding problems.

Distortion

When metal is heated it expands, and as cooling occurs it contracts. Distortion in welds results from uneven expansion and contraction of the weld metal and workpiece during heating and cooling.

To understand how and why distortion occurs, consider the steel bar shown in Figure 8.1.

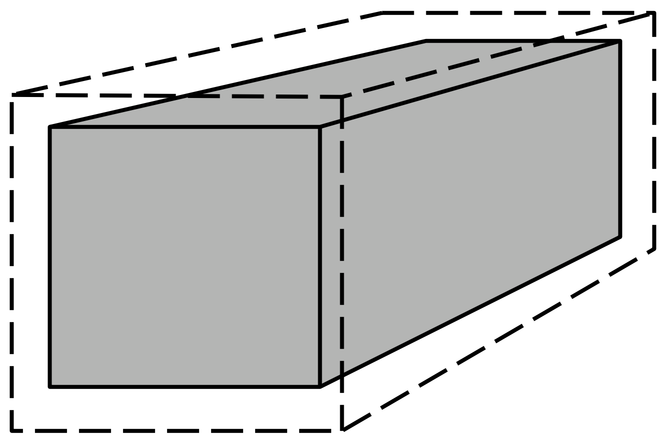


Figure 8.1

As the bar is uniformly heated, it expands in all directions. As the bar cools to room temperature, it contracts uniformly to its original size.

If the bar is restrained (ex. held in a vise as shown in Figure 8.2), lateral expansion cannot take place.

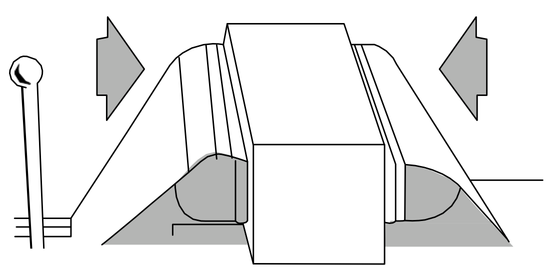


Figure 8.2

Since heat causes volume expansion, the bar must expand. In Figure 8.3, expansion occurs only in the vertical and longitudinal directions.

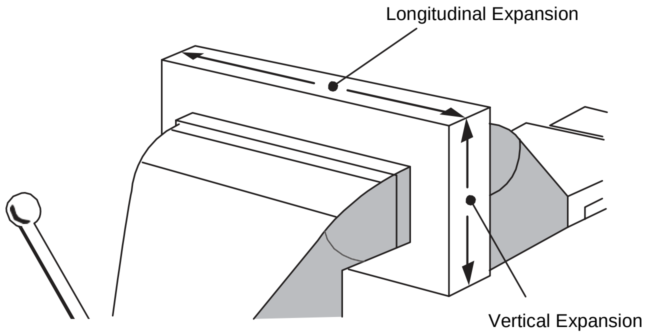


Figure 8.3

As cooling occurs, the bar contracts uniformly in all directions until it reaches room temperature. At this point the bar has become thinner and longer than before. Permanent distortion has occurred.

The same process occurs when a joint is welded. The metal is in its maximum expanded state when it is molten. As the weld metal cools and solidifies, it attempts to contract but is restrained by the workpiece metal that has been welded. This shrinkage of the molten metal as it cools creates a twisting or pulling force which distorts the original shape of the metal.

The more heat that is applied to a weld, the greater the distortion. The larger the weld bead applied to an area, the more heat that is applied resulting in more distortion.

Types of Distortion

Distortion can be caused by the way the weld is applied to the workpiece, the thickness of the metal, or the strength of the structure being welded.

There are three common types of distortion:

1. Lateral Distortion

Lateral distortion occurs when the metal shrinks laterally from its original size during cooling.

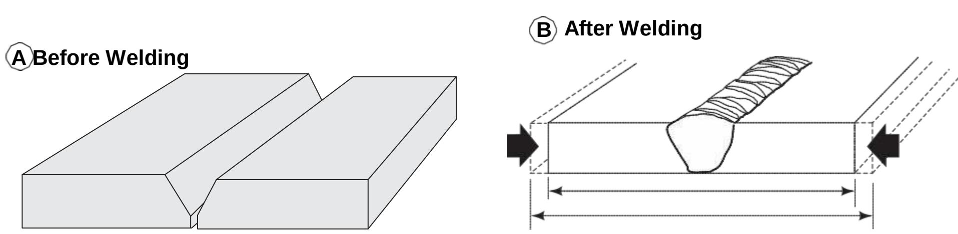


Figure 8.4 - Lateral distortion

2. *Longitudinal Distortion*

Longitudinal distortion occurs when the metal shrinks from its original length.

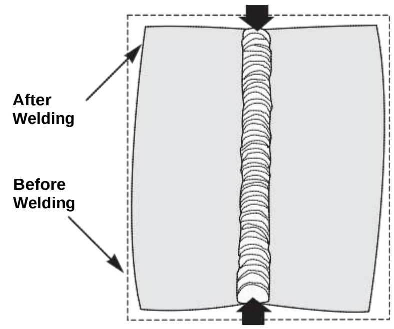


Figure 8.5 - Longitudinal distortion

3. *Angular Distortion*

Angular distortion occurs when the shrinkage forces cause the workpiece to be pulled from the original horizontal or vertical plane. Figure 6 illustrates angular distortion in tee and buttjoints.

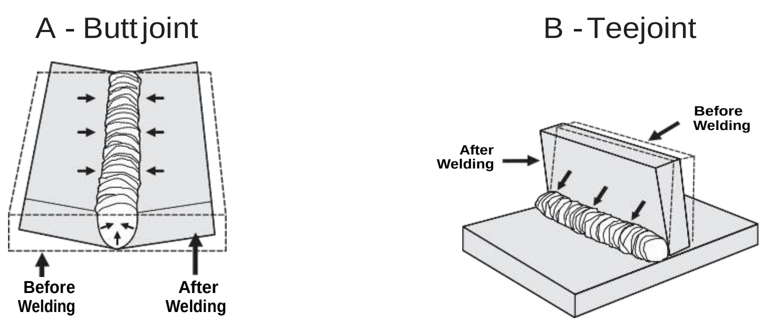
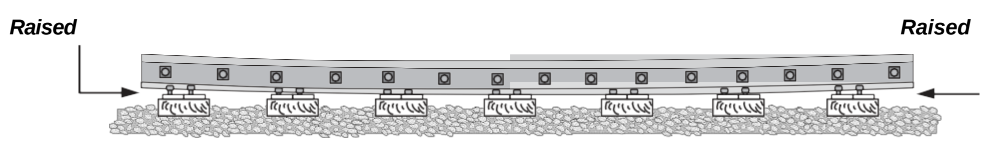


Figure 8.6 – Angular distortion

The following is an example of angular distortion in welding caused by longitudinal contraction.



Distorted piece, with ends off the plates (It could be a piece of rail, metal plate, etc...

Figure 8.7

When the weld or hot metal has cooled, longitudinal contraction of the weld or hot metal shortens the welded side, resulting in angular distortion.

How to Control Distortion

The following illustrations show methods for controlling distortion when welding or heating metal.

1. Secure the Joint

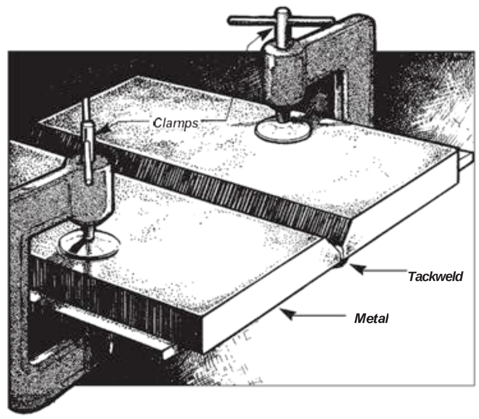


Figure 8.8 - Clamping or tack welding abutt joint

If a joint is constrained or secured by a tack weld, clamp, or jigs, distortion cannot occur. Using tack welds in fact is the most common way to avoid distortion. When welding, you should decide what kind of distortion you will have to control, and secure the weld accordingly. (Note: with practice on the job, you will develop skill at predicting the type and amount of distortion that will occur.)

2. Do Not Over weld

As you learned earlier, the thickness of the weld should correspond to the thickness of the thinnest metal used in the joint. In Figure 8.9a, that means dimensions 1 and 2 should be equal. If they are equal, you will get a slightly convex weld.

However if the weld is highly convex in shape (dimension 3) there is excess metal on the weld. This excess metal does not increase the strength of the weld, but it does, however, increase the shrinkage forces and distortion.

You can avoid over welding by:

1. using an electrode diameter that is just sufficient for the thickness of the workpiece, and
2. ensure the travel speed is fast enough so that buildup does not occur.

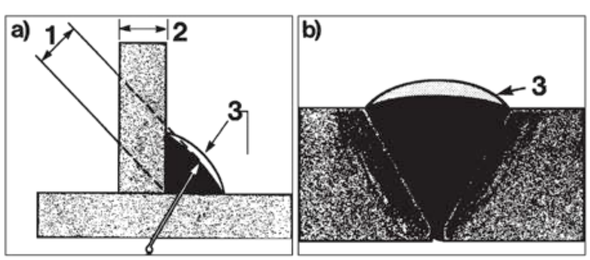


Figure8.9-Over welding

3. Use a Double Groove Weld

Where applicable, you can use a double groove weld to minimize distortion. It will balance the impact of shrinkage on each side of the weld.

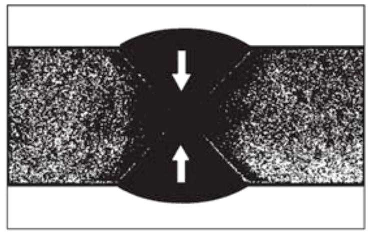


Figure 8.10- Jointselection

Figure 8.11

Apply only the weld metal that is required, in equal amounts when the «Double V» method is used.

4. Use Sequence Welds

A weld that is deposited in sections on either side of a joint, balances the effects of distortion.

Figure 8.12 illustrates a double groove weld on a butt joint welded in alternating sequence.

a) Butt joint

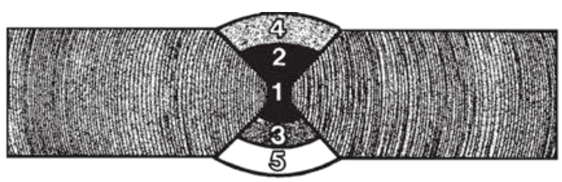


Figure 8.12

Figure 8.13 illustrates two other methods of sequence welding.

b) Teejoint

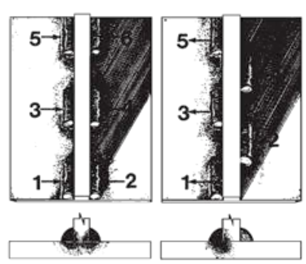


Figure 8.13

5. Use Back-step Welding

If you were to weld along the butt joint shown in Figure 8.14 starting at one end and welding continuously to the opposite end, distortion would occur. To prevent this, welds can be applied in sections as shown, with each new section of the weld ending where the previous one began. This is known as back-step welding.

With this method, different parts of the workpiece are heating (expanding) and cooling (contracting) at the same time. This minimizes the cumulative impact of heating and cooling and is particularly recommended for long weld beads.

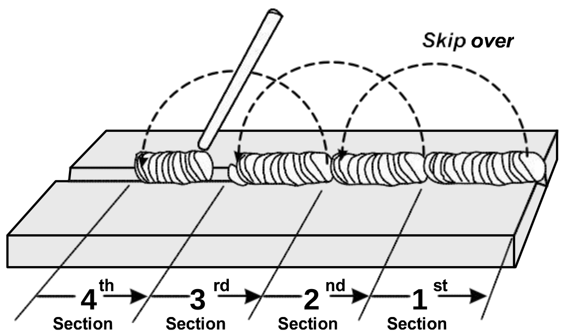


Figure 8.14- Back-step welding

6. Use Intermittent Welding

The amount of heat applied to a joint can be minimized by reducing the amount of weld metal deposited.

By placing intermittent, rather than continuous welds on a joint, you can reduce the amount of metal deposited by up to 75% and still provide adequate weld strength.

As Figure 8.15 indicates, intermittent welding resembles the application of large tack welds.

Figure 8.15-Staggered intermittent welds/ chain intermittent welds

7. Pre-setting the Joint

Pre-setting a joint before welding it uses shrinkage to your advantage. Before welding, pre-setting the joint requires that you purposely place joint parts out of position.

The required amount of pre-set can be determined from a few trial welds and from practice. Remember the larger the weld applied, the more shrinkage that will occur and the more pre-set that is required.

Figure 8.16 shows examples of pre-set tee and butt joints.

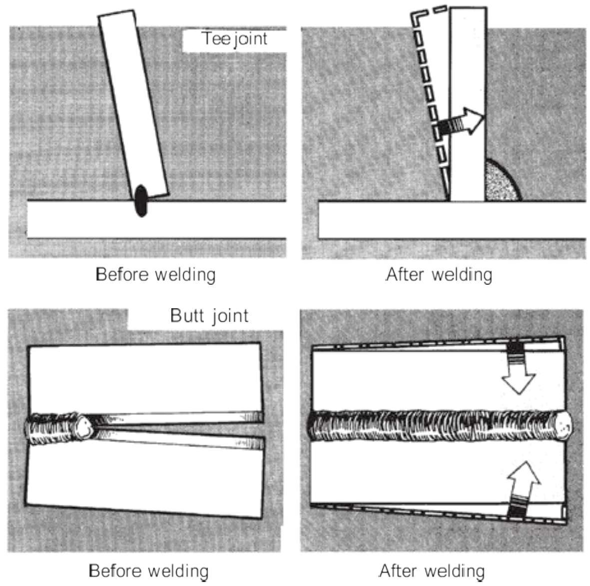


Figure 8.16 - Pre-setting joints

8. Controlling Distortion by Pre-bending

One method of controlling the effects of distortion is to use restricting devices or to pre-bend the material to be welded. By pre-bending the weld zone, and clamping the total structure, any distortion of the material, caused by the welding heat, will be overcome, and the entire unit will return to its original shape on cool out.

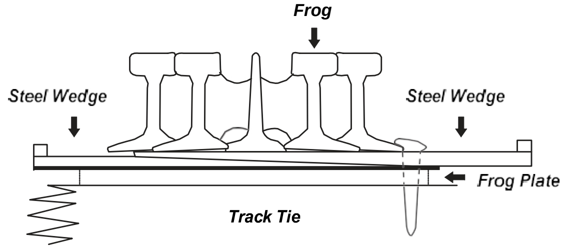


Figure8.17-Restrictingdevicesusedinwelding

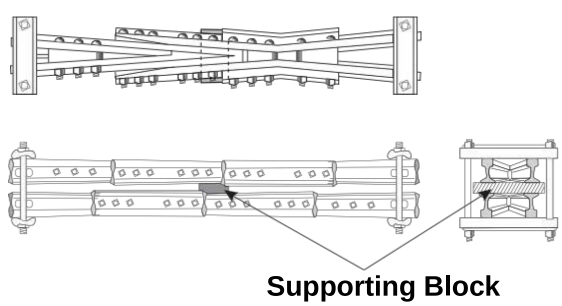


Figure 8.18

Note: When restricting devices are used, you must keep in mind that there will be some spring back of the metal when the devices are removed. (If you are working on chrome or LAHH [Low Alloy Head Hardened] track components, make sure to confer with the welding supervisor as the procedure is not the same for these types of metal.)

9. Additional Ways to ControlDistortion

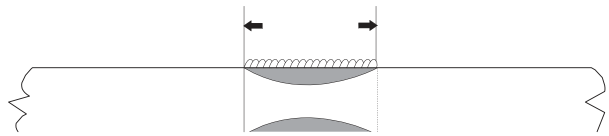


Figure 8.19

Opposing the heat is a method often used in track welding.

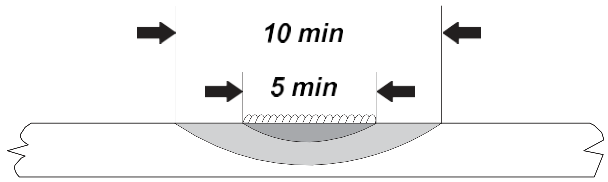


Figure 8.20

Keep welding time to a minimum. The longer welding is carried out, the more heat that is absorbed by the surrounding metal. Weld as quickly as possible, but maintain the quality of the work as speed increases.

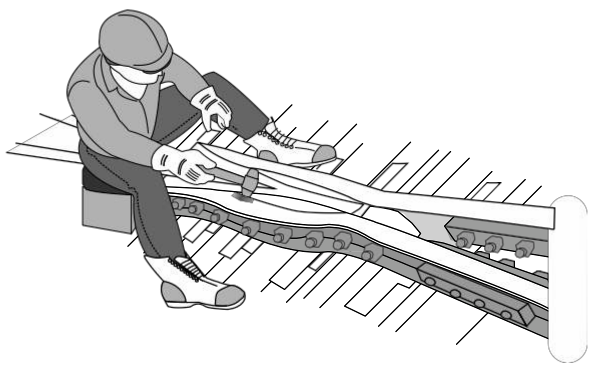


Figure 8.21

Peen the weld to stretch the weld metal. This method is also used in austenitic manganese repair.

Use of the Restricted Expansion Method for Straightening Metal Sections

Distorted sections can be thermally straightened by rapidly heating the area at the convex portion of the bend, concentrating the heat in the area where the most contraction is desired.

This technique can be used to straighten pieces of railroad equipment. A great deal of practice is required to master this procedure.

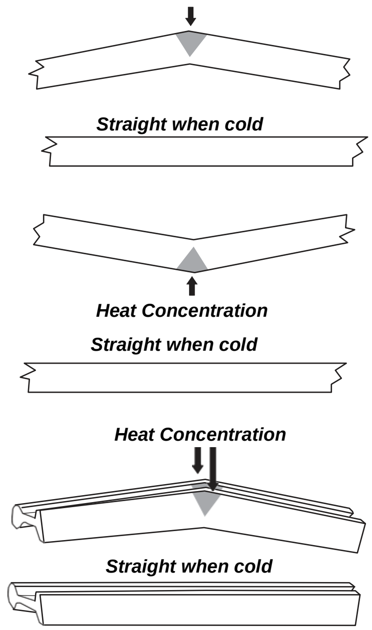


Figure 8.22- Thermal straighten ingot metal sections

Weld Defects

Defects weaken the weld. Just like a chain, a weld is only as strong as its weakest link. Here are five common weld defects.

1. Overlap
2. Undercut
3. Porosity
4. Spatter
5. Craters

1. Overlap

Overlap occurs when the weld metal builds up and rolls over at the edges, causing improper fusion with the workpiece. (Overlap is sometimes called “cold lap.”) When this happens, the weld may look strong, but in fact, it is likely to break. Figure 8.23 shows a 15 mm (5/8") wide weld with an overlap of 3 mm (1/8") on each side. This results in a weld with the strength of a 10 mm (3/8") weld.

Causes of Overlap

Overlap occurs when:

a) The travel speed is too slow causing too much weld metal to build up.

b) The amperage setting is too low to melt the workpiece causing the filler metal to build up on the workpiece.

c) The arc length is too short to allow the weld metal to spread out on the workpiece.

d) The electrode is not held at the correct angle (90° to the workpiece for a butt joint, 45° to the workpiece for a tee joint) and excessive buildup occurs on one side of the weld.

Figure 8.23 shows two examples of excessive overlap.

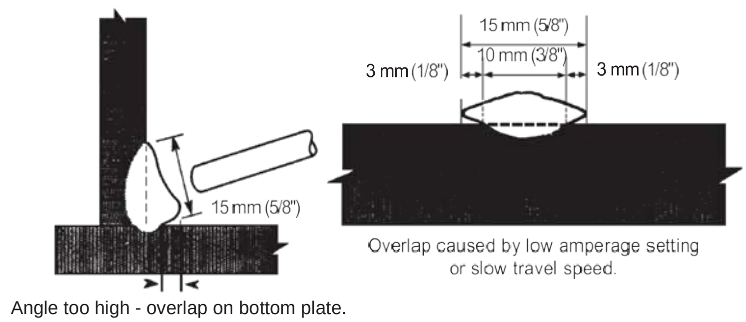


Figure8.23-Twoexamplesofexcessiveoverlap

2. Undercut

Undercut is characterized by a groove that appears on one or both edges of the weld bead. The groove is cut into the workpiece by the arc and occurs when there is insufficient weld metal to fill the groove as the weld progresses. Undercut weakens the weld by making the original thickness of the workpiece thinner. Figure 8.24 shows a workpiece 8 mm (5/16") thick with an undercut 1.5 mm (1/16") deep. In this example, the workpiece is reduced to the strength of a 6 mm (1/4") piece.

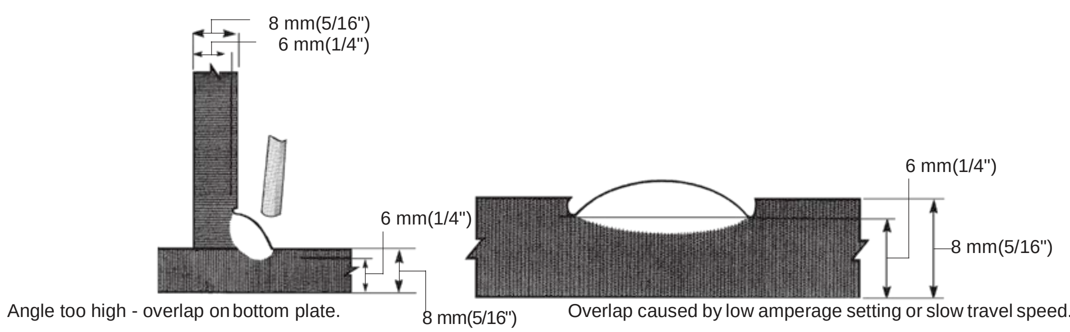


Figure8.24– Two examples of undercut

Causes of Undercut

Undercut is caused:

a) When the travel speed of the electrode is too fast, and the filler metal does not have achance to fill the groove along the edge of the weld bead.

b) When the amperage setting is too high causing the arc to melt a groove along the edge of the weld.

c) The electrode is not held at the correct angle * (90° to the workpiece for a butt joint, 45° to the workpiece for a tee joint) and excessive buildup occurs on one side of the weld.

* Note that an incorrect angle may result in either overlap or undercut.

3. Porosity

Porosity refers to tiny air pockets or holes in the weld or on the surface of the weld. Porosity causes the weld to weaken and under load it may break.

a) Surface porosity

b) Internal porosity

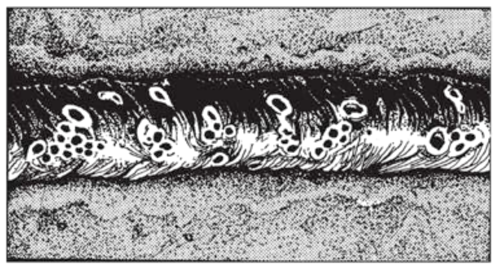


Figure 8.25

Causes of Porosity

Porosity is caused:

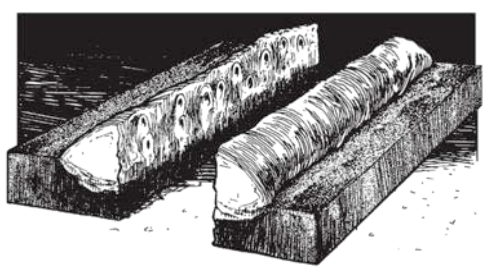


Figure 8.26

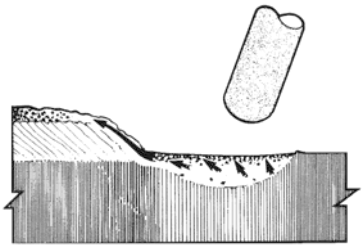
a) When the travel speed of the electrode is too fast. Impurities in the molten puddle normally rise to the surface of the weld and become part of the slag covering when the weld cools. When the travel speed is too fast, the metal does not stay molten long enough to allow the impurities to rise to the surface, and air pockets are created in the weld.

b) When the workpiece contains a lot of moisture, you should pre-heat the workpiece before attempting to weld.

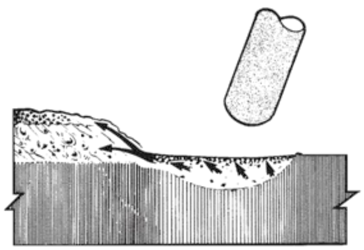
c) If the arc length is too long and the gaseous shield is not concentrated enough to protect the molten puddle from the atmosphere.

d) Arc blow can also cause porosity to occur.

4. Spatter



Impurities normally rise to the surface and become part of the slag covering.



Impurities that are trapped in the weld will cause porosity.

Figure 8.27

Spatter consists of small globules of molten metal that fly out of the molten puddle or off the electrode. Spatter sticks to the weld bead and the workpiece causing poor appearance. Spatter is also a sign of a poor weld which may break.

Causes of Spatter

Spatter may be caused:

a) By using the wrong electrode or polarity, so the metal from the electrode does not melt and mix properly with the workpiece metal.

b) By setting the amperage too high, causing turbulence in the puddle.

c) If the arc length is too long, resulting in filler metal spraying too widely over the weld bead.

5. Craters

Craters are depressions in the weld that are formed when the electrode is pulled out of the molten puddle too quickly. When this happens, the filler metal from the electrode does not have a chance to fill the depression. Craters can form when you stop to change electrodes or at the end of a weld. Craters cause a stress point in the weld bead and, while cooling, may form a crack that runs the entire length of the weld. Craters must be filled to prevent this from happening.

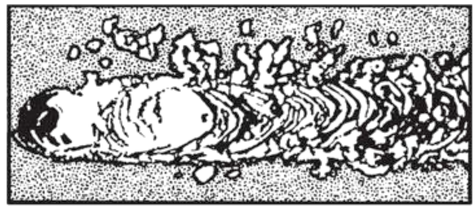


Figure 8.28

Craters must be filled, bringing them up to the height of the weld bead. To fill a crater after stopping in the middle of a bead, first chip the slag out of the crater and for at least 13 mm (1/2") along the last portion of the bead. Re-strike the arc 6 mm (1/4") ahead of the crater, move the arc back into the crater, and then continue ahead with the bead.

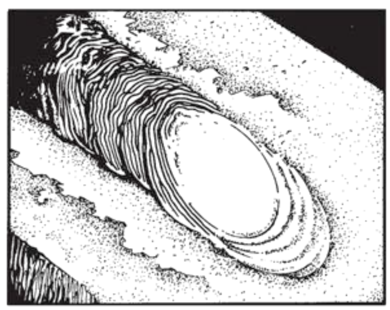


Figure 8.29

When completing a bead, there will always be a slight crater but by welding back into the bead deposit and then breaking off contact, it will be minimized.

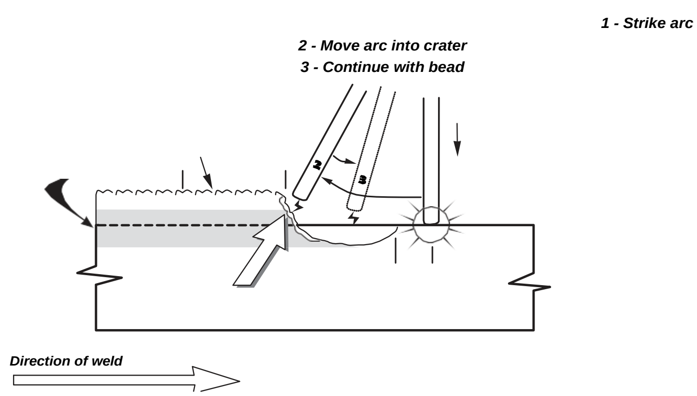


Figure 8.30

To fill a crater at the end of a weld, draw the electrode up slowly and weld backward over the completed weld. Do not weld back into weldment which still contains slag coating. By slowly drawing the electrode out, the crater is filled with weld metal.

Arc Blow

Arc blow is another problem welders' encounter. In this situation, the arc has a tendency to wander or stray from the natural path between the electrode tip and workpiece.

Figure 8.31 illustrates an example of arc blow in which the arc strays from its natural path and instead blows in the direction of travel.

Arc blow only occurs when DC power is used. The reason is as follows. A magnetic field is created whenever there is a flow of current. Several factors can cause the magnetic field to become misaligned, for example an angular surface. Because DC current flows in one direction, a misaligned magnetic force will pull the arc towards it.

In AC current arc welding, arc blow will not occur. The current flow changes direction rapidly, so the magnetic field also changes direction, canceling or counteracting arc blow and stabilizing the arc.

Arc blow will also cause difficulties in handling the molten puddle, resulting in excessive spatter, incomplete fusion, porosity, and poor quality welds.

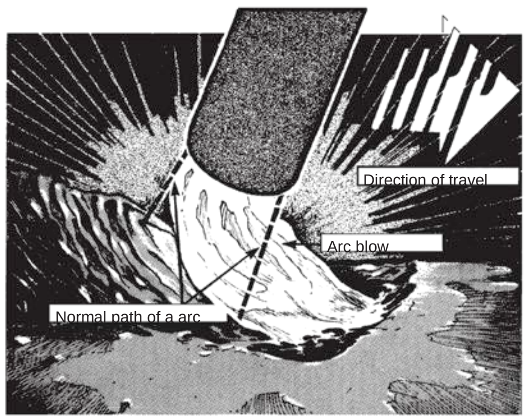


Figure 8.31

How to Control Arc Blow

1. Change to AC current as previously mentioned if possible.
2. Establish the shortest arc possible. A longer distance between the tip of the electrode and the workpiece allows a greater distance for the arc to wander. A short distance will reduce the amount of straying.
3. Reduce the weld current. The greater the current, the greater the arc force. So by reducing the current, you will in turn reduce arc force and arc blow.

4 Angle the electrode in the direction of the arc blow. This will counteract the force and use it to your advantage to produce good welds.

5. The location of the ground clamp on the workpiece will affect arc blow. The arc tends to blow away from the ground clamp. You should therefore weld away from the ground clamp to use arc blow to your advantage, or change the position of the ground clamp so arc blow will be directed in the direction you are welding.

6. When welding in corners where there are numerous angles and joints, always weld intothe corner to curb arc blow. This procedure uses arc blow to youradvantage.
7. If possible, you can wrap the ground clamp cable around the workpiece.

Crystallization

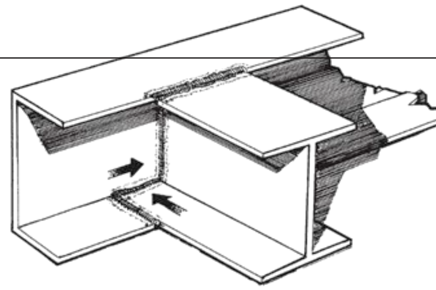


Figure 8.32-Weld into corners to avoid arc blow

One other problem that results from heating metal is crystallization.

When metal is welded, the surrounding area of the joint is heated to various temperatures. The temperature from the weld joint outward is called a temperature gradient. On a common weld bead, the gradient may vary from 2000°F to only 500°F on the outer side of the weld joint.

In welding it is the metal's crystalline structure that expands and contracts when the metal is heated and cooled. Once heated, the crystals return to their normal size unless this temperature is held above 2350°F for any length of time. If this occurs, the crystals will expand to their largest size and will not return to their original size during cooling. This is known as crystallization. Crystallized metal becomes brittle and will break.

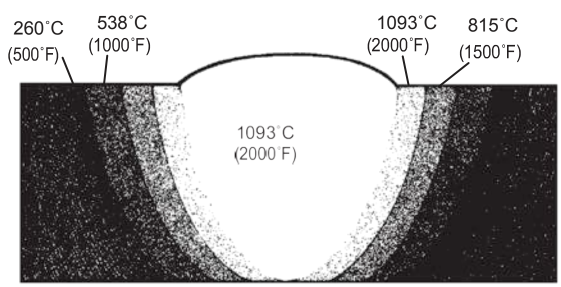


Figure 8.33- Temperature gradient of a weld

Avoiding Crystallization

Crystallization can be avoided by reducing the amount of heat applied to the weld. Applying several smaller passes with low amperage produces less heat at the weld than applying one large pass at high amperage.

Crystallization can be avoided by:

1. applying multiple rather than single weld beads where possible, and
2. allowing the work piece to cool down between individual applications of multiple beads.

Chapter 9: Rail Joint Welding - Electric-Arc Method

Introduction

The purpose of electric rail-end welding is to build up the worn or battered ends of the rail with weld metal.

These built-up rail-ends when subjected to the pounding of wheels:

1. Will have a durable inseparable bond with rail base metal.
2. Will be harder than the rail steel and minimize batter.
3. Will not be so hard that they will spall.

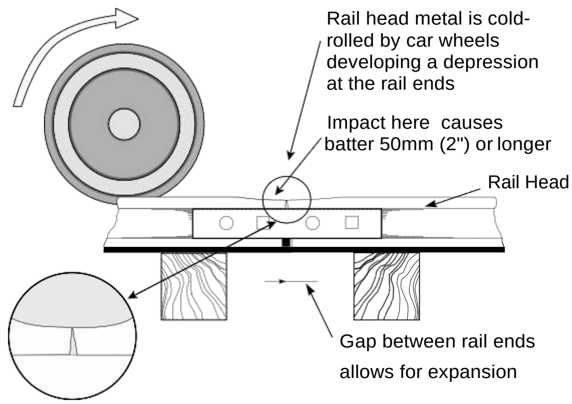


Figure 9.1- Rail joint welding

Pre-welding requirements

a) Bolt tightening and surfacing may have to be performed to ensure a solid foundation before applying the weld.

b) (i) The use of the oxyacetylene cutting torch to remove defective metal is strictly forbidden.

(ii) Carbon arc gouging is not permitted on any rail steel.

(iii) Absolutely no oxyacetylene flame cutting or welding, or arc cutting in any form is permissible on chrome alloy rail components.

(iv) To prevent heat build-up, coarse snagging wheels and light to medium pressure must be used in all grinding.

c) A Straight Edge must be employed to determine the weld limits.

Preheating

Sudden heat generated by the electric-arc applied to non-preheated high carbon / alloy steel, causes thermal shock. The shock occurs when the small super-heated part of the metal is subjected to sudden quench from the surrounding cold metal. The results are cracking of the weld bead and/or base metal near or under the weld bead. The physical properties are also alteredin the heat affected zone, and the metal becomes brittle.

To avoid thermal shock, all rail steel must be preheated **before arc-welding.**

If a metal rod is heated a distance back from the end you will find that the heat runs toward the end of the rod but that it is always the last to cool. Therefore, as the ends of the rail cool last and so cool slow, the preheating must be concentrated at the weld limits where the heat dissipates faster. The method of preheating requires the use of two baffle boxes or a “Rexotherm” heater in-which propane burns and heats the rail ends. The distance between the baffle boxes may be varied so that they may be placed one on each rail end, straddling the outer weld limits of each rail.

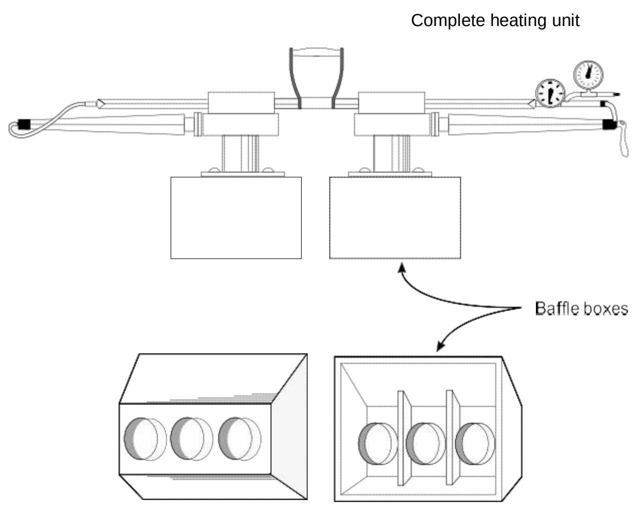


Figure 9.2- Tele-weldpropane heater

Preheat at least 100mm (4”) beyond the actual weld limits on most rail chemistries and up to 250mm (10”) beyond when preheating LAHH alloy and chrome. The weld limits are the critical areas, but the entire intended weld surface must be brought to a uniform preheat temperature.

700°F (389°C)	– Standard chemistryrail
800°F (444°C)	– Low alloy chemistryrail
“ “	– Chrome chemistryrail

Boxes need not be placed closer than 50mm (2”) from the end of the rail. Use a Temperature indicating crayon as a guide to determine when the correct temperature is reached after which welding may commence.

Preheat temperature must be maintained throughout the welding operation and repeated applications of heat may be called for particularly in cold weather.

In no instance should the preheat temperature exceed the stated minimum by more than 300°F (167°C).

Special note:

Attach the ground clamp to the rail to be welded not more than 610mm (24”) from the working point. The base of the rail must be lightly ground prior to applying the ground clamp. This will eliminate arc burns. Grind off oily and rusty metal surface to ensure that the ground clamp makes full contact without excessive electrical resistance. The magnet type grounding device must be applied on a clean surface on the rail head as close as possible to the work being done. The ground connection must be on the same rail that is to be welded and must be moved from joint, to joint, as the welding progresses. Under no circumstance leave the ground on one rail and touch the electrode to the opposite rail.

This is vitally important on signal controlled track. Failure to heed this rule will cause the high amperage welding current to flash back through the signal circuit, burning out electrical relays and/ or electronic equipment that will put the signal system out of operation and cause train delays.

Welding procedure

a) It is essential that the work zone be protected from wind and strong draughts which may destroy the gas shield and produce an inferior weld (This protection is also necessary during preheat and post-heat operations).

b) Any excavated areas should be built up to the level of the surrounding areas prior to further build up.

c) Weld beads must be thoroughly cleaned of all slag by chipping and wire brushing after each pass. If slag is accidentally trapped in a weld or if any weld defects occur, they must be removed by grinding before welding continues.

d) After slag removal, and while the weld deposit is still hot, weld beads should be **lightly** peened to relieve stress.

e) There are a number of weld patterns, which are used in rail-end welding. While patterns may differ, the end result of each must be the same smooth and even running surface for the wheels to travel over.

f) The weld build-up must not extend past the end of the splice bars.

Two common weld patterns are shown below.

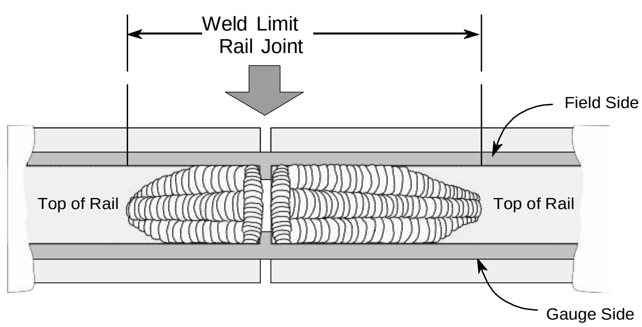


Figure 9.3

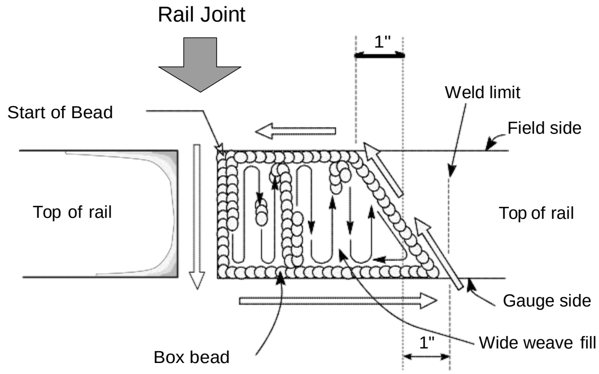


Figure 9.4

g) Other suggestions include:

(i) When using stick electrodes, deposits should be made in a series of weld metal pads, each deposition equivalent to the length of one complete electrode. A short arc length will help to avoid craters at the finish of the weld bead and a weave not more than twice the diameter of the electrode is recommended. Starts, joints, and finishes of runs should be staggered across the rail head.

(ii) When using wire electrodes, build up the area in a series of pads up to 200mm (8”) in length using a weave of 20 to 25mm (3/4” to 1”) width aiming to complete a pad in about 2 minutes. A deposit height of 1 mm to 1.5mm (3/64” to 1/16”) per pass should be achieved. Start and stop positions should be staggered.

Reminder

Electrodes must be kept in a dry storage area. As an extra precaution, it is recommended at least one day’s supply be heated in an appropriate electrode oven the day before use. This also applies for wire feed.

Surface grinding

Hot steel is much more easily ground, with less effort and abrasives than cold steel. Surface grinding should be done immediately after welding if possible. The joint must be ground so as to leave a level, smooth running surface when the weld has cooled, rounded to the contour of the existing rail with no sharp edge of weld metal exposed. Grinding tolerances are 0.25mm (.01”) high and zero (0) low.

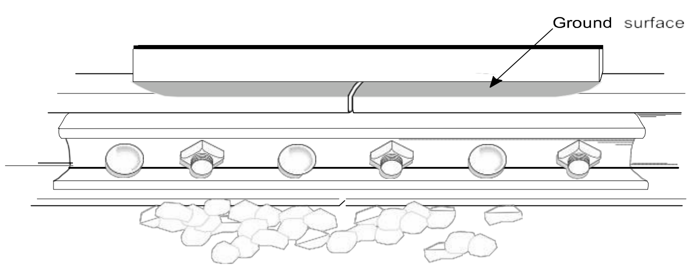


Figure 9.5

Grind as soon as possible. When the rail (all chemistries) has cooled to about 700°F (389°C), the post heating operation must begin. Complete grinding after cool-out if necessary.

Rail-endslotting

The rail-ends must be slotted as prescribed in GTS 1113 ensuring that there is no protrusion on the vertical rail-end face which will with normal rail expansion cause a chipped joint.

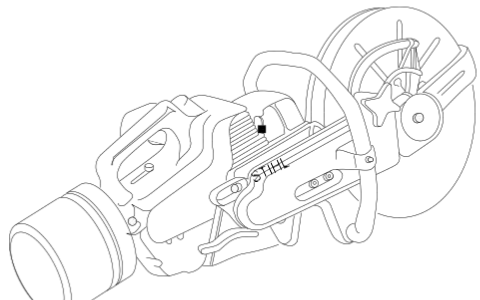
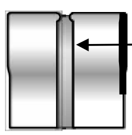


Figure 9.6 TS08 Rail Slotter

GTS 1113

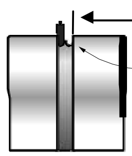
Insulated Joint Slotting

Typical Flowed Rails



Insulated end post
9.5 mm thick

Double Cut

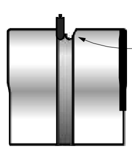


Slot-To width of end post

All end overhang to be removed leaving rail ends squared and perpendicular.

Depth of cut will necessitate some cutting of end post.

Bevel Detail

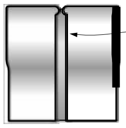


Bevel both rails if cut depth exceeds 4 mm;

Otherwise 4 mm depth of cut automatically forms bevel end post notched from double cut.

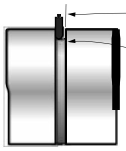
Bonded Insulated Joint Slotting

Typical Flowed Rails



Insulated end post
4.8 mm thick.

Double Cut



Slot-Approximate wheel width 3.75 mm.

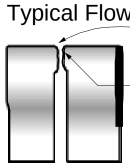
All end overhang to be removed leaving rail ends squared and perpendicular.

Depth of cut will necessitate some cutting of end post

Note: No beveled mitres required as this will create a batter condition.

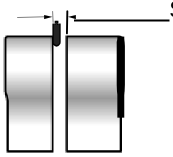
Flowed Rail End Slotting Wide O pen Joint

Typical Flowed Rails



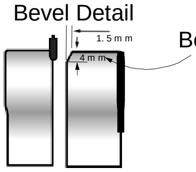
Excessive flow
End batter flow

Double Cut



Slot - To restore expansion gap.
All end overhang to be removed leaving rail ends squared and perpendicular.

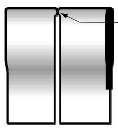
Bevel Detail



Bevel Both Rails

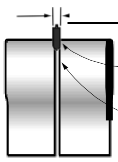
Flowed Rail End Slotting Slightly O pen Joint

Typical Flowed Rails



End Batter Flow

Single Cut

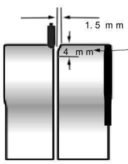


Slot - Approximate wheel width 3.75mm.

All end overhang to be removed.

Cut to be evenly divided in both rail ends.

Bevel Detail

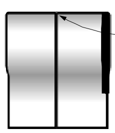


Bevel both rails if cut depth exceeds 4 mm;

Otherwise 4 mm depth of cut automatically forms bevel.

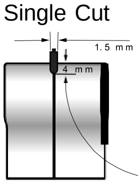
Flowed Rail End Slotting Closed Joint

Typical Flowed Rails



End batter flow.

Single Cut



Slot- Approximate wheel width 3.75 mm.

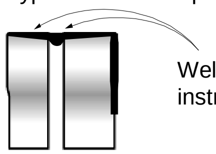
Cut to be evenly divided in both rail ends.

Depth of cut to be 4mm.

N o t e: No special beveling required 4mm depth of cut automatically forms bevel.

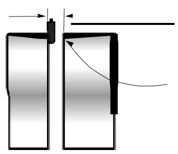
Welded Detail Ends Slotting Wide O pen Joint

Typical Welded O pen Joint



Welded joint batter for instructions

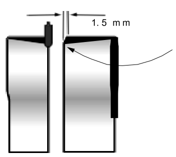
Double Cut



Slot -To restore expansion gap.

All end overhang to be removed leaving rail ends squared and perpendicular.

Bevel Detail

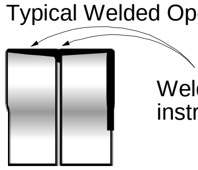


Bevel both rails.

Depth of bevel 4mm.

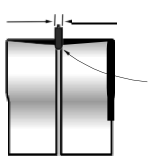
Welded Rail Ends Slotting Slightly O pen Joint

Typical Welded Open Joint



Welded joint batter for instructions

Single Cut

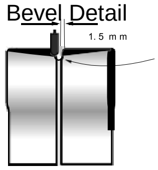


Slot-Approximate wheel width 3.75 mm.

All end overhang to be removed. Minimum depth of cut 2 mm below weld.

Cut to be evenly divided in both rail ends.

Bevel Detail

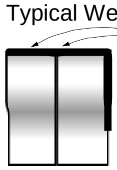


Bevel both rails if cut depth exceeds 4mm;

Otherwise 4 mm depth of cut automatically forms bevel.

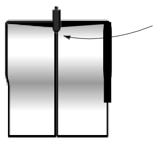
Welded Rail Ends Slotting Closed Joint

Typical Welded Closed Joint



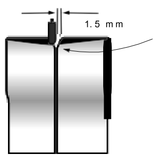
Welded joint batter for instructions

Single Cut



All end overhang to be removed. Minimum depth of cut 2mm below weld. Cut to be evenly divided in both rail ends.

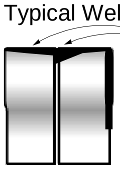
Bevel Detail



Bevel both rails if cut depth exceeds 4mm; Otherwise 4 mm depth of cut automatically forms bevel.

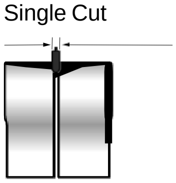
Weld of Chip Joint Slotting Slighting Open Joint

Typical Welded Chip Joint



Welded joint batter for instructions

Single Cut

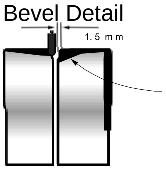


Slot-Approximate wheel width 3.75 mm.

All end overhang to be removed. Minimum depth of cut 2 mm below weld.

Cut to be evenly divided in both rail ends.

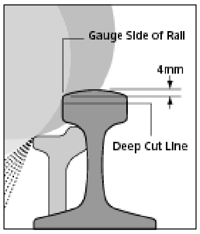
Bevel Detail



Bevel Both Rails

Depth of Bevel 4 mm.

Details-Gauge Side Slotting



Maximum position of grinding wheel for all insulated joints and where 4mm depth head cut only is required.

Maximum position when deep cut is required to remove excessive overhang.

Gauge side of rail must be slotted as deep as possible without nicking splice bars or insulated joint bars.

Notes:

1 Slotting shall be performed with a machine securely held so that the accuracy of cut is assured.

2 The gauge side of the taper shall extend downward toward the edge of the rail head as far as possible. Care must be taken not to nick the splice bar, or the bonded joint.

3 To prevent interference of signal function. An insulating material must be placed between the clamping device and the rail ends when slotting insulated and bonded joints. All grinding filings are to be brushed or blown out of the joint area.

Post-heating and control cooling

Without post-heating and controlled cooling a hardness pattern ranging from soft or medium at the rail-end to extreme hard at the weld limits could develop. This must be avoided.

When the weld has cooled to 700°F (389°C), position the post heater so as to straddle the weld limits. Adjust them as required during the operation, to post heat the entire weld area and 50 mm (2”) beyond the weld limits to 1100°F (611°C) for standard and 3HB, and 10” beyond at 1200°F (667°C) for chrome and low alloy rail.

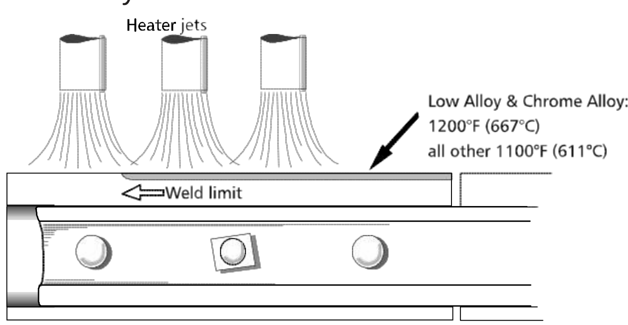


Figure 9.7

As when preheating, post-heating heaters need not be placed closer than 50 mm (2”) from the end of the rail.

In rainy or snowy weather conditions or when the ambient temperature is below 0°C (32°F), Standard and Hi Si rails must be covered immediately after post-heating with a heat retarding cover. This cover or blanket should be placed on the rails and left in place until the rails have cooled to 392°F (218°C). Remove the cover or blanket and protect the joint from direct wind, allowing the rails to finish cooling in relatively still air.

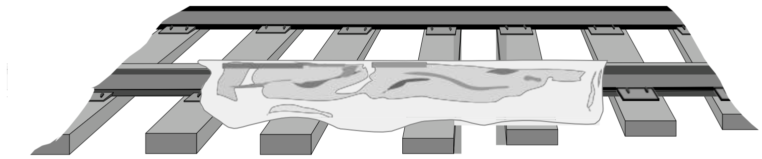


Figure9.8-Refractoryceramicfibreblanket

Note:

In all weather conditions and at any air temperature, when the chrome/alloy rail weld has cooled to 700°F (389°C) the weld must be post-heated to 1200°F (667°C). It is also essential to control the cooling rate of the weld and the heat affected zone to avoid the formation of martensite (a brittle metal structure).

The cooling rate of chrome rail must not exceed:

- .9°F (.5°C) per second between 1472°F (817°C) and 752°F (418°C) = 13 minutes and 20seconds.
- 4.5°F (2.5°C) per second between 752°F (418°C) and 392°F (218°C) = 1 minute and 20seconds.

Hardness

The hardness of the weld metal at the weld limits must not be more than 20 BNH higher than the rail steel. The hardness of repaired rail-ends must be spotchecked.

Figure 9.9

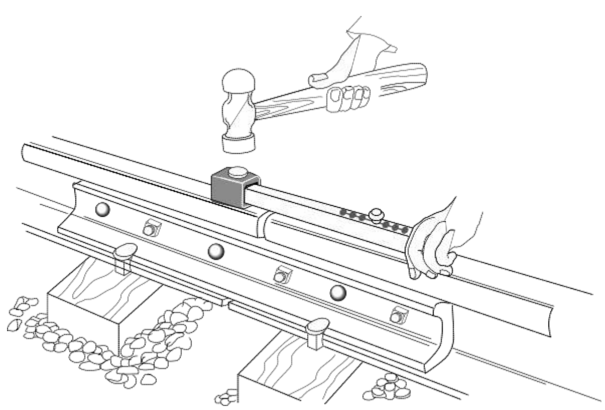


Figure 9.10 - Brinell Tester being used

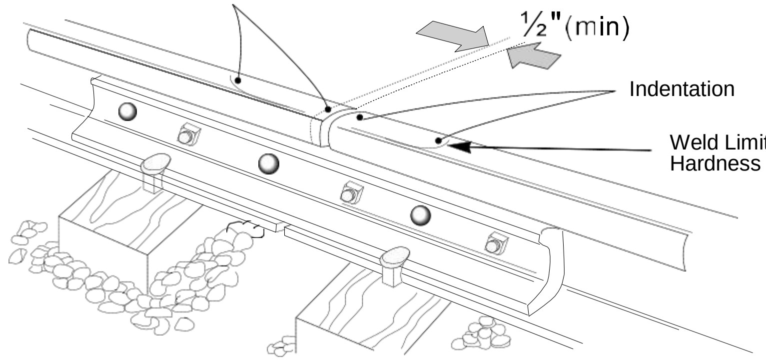


Figure 9.11- Hardness limits

Welding of insulated joints

1. Advise the signal maintainer to be on hand.
2. Remove the insulated joint bars and install standard splice bars, one joint at a time.
3. Carry out weld repair.
4. On cool out install insulated joint bars.

Emergency repair of insulated joints in the field by electric arc-welding

When undertaking electric arc welding of bonded insulated joints in the track there are some very important items, which must be kept in mind.

1. Choose the proper, approved type of welding electrode or wire.
2. Straightedge the joint properly to determine depth and weld limits.
3. Welding of the rail-ends in a bonded insulated joint should preferably be done when therail temperature is above 37.8°C(100°F).
4. Use fusal paste on the center post of the insulated joint and on the top flanges of the insulated bars.
5. Place the specially designed insulated brass plate on the joint.
6. Rapidly preheat weld area to 400°F (222°C) with an approved propaneheater.
7. The ground connection must be applied not more than 24” from the working point on the same rail end being welded prior to attaching the ground clamp to the base of the rail. You must lightly grind a spot to attach the clamp. This procedure will eliminate any arc burn.
8. Carry out welding as quickly as possible.
9. Post heat is not advisable but heat retardant blanket should be used to control cooling rate.
10. Again, it must be stressed, the application of ground cable is to be on the same rail as being welded.
11. Under no circumstances, strike an arc on the opposite rail. It will short circuit signal systems and shut down train operations.

12. Surface grinding must be done until the joint is ground level and contoured to suit the existing rail shape
13. Surface grinding and slotting of all built-up rail ends must be completed by the close of work each day.
14. Do not apply oil or grease on finished insulated joints.

Preventive measures

1. When working on live track operating any equipment, it is essential that one employee act as a dedicated lookout, this is known as the “Watchperson/Lookout.”
2. The dedicated lookout person must never engage in other tasks, which could interfere with the responsibility of protecting others, but must watch for oncoming hazards in all directions.
3. The proper eye protection is required to prevent arc flashes. The minimum color grade is welder’s green 3 but 5 is preferable.

Remember:

The safety watch – is a watch for life!

Welding rail end batter

1. This circular covers:
   a) Planning for repair of battered rail ends by welding.
   b) Preparation of track for welding.
   c) Repair of battered rail ends by the electric arc method.

Planning for welding

2. The SUPERVISOR shall initiate the planning of welding on the basis of a survey of rail conditions.
3. a) Only rail ends having a batter in excess should be repaired by welding.
   b) When 60% or more of the rails have end batter in excess of 3 mm (0.12 inch), they should be removed from track.
4. a) Out of face welding should be undertaken when at least 60% of the rail ends have a batter of 1 mm (0.04 inch) or more.
   b) Mismatched rails should be welded or ground.
   c) Rails containing defects, having excessive wear in the fishing area, or which are kinked or surface bent, shall not be welded.
5. Measurement of batter shall be made with a steel straight edge and a tapered feeler gauge.

Preparation of track for welding

6. In accordance with item 4 above replace rails that should not be welded.
7. Oil should not be applied before joint welding.

8. Standard splice bars must replace insulated joint bars during welding. The work must bein accordance with G) Track Standards section 7 – FieldWelding.

Repair of rail end batter

9. Welders repairing battered rail ends must be qualified by the SUPERVISOR in the techniqueto be used.
10. Immediately prior to welding, the person in charge of the gang will mark the joints for repair welding.
11. The welding of rail ends must be carried out in accordance with the technique approved by Corridor Maintenance Senior Manager of Track and Structures.
12. When welding by arc method, areas of the rail head affected by welding heat must be pre and post heated.

Pre-heat	Post-heat
700°Fahrenheit (389°C) for STD &3HB rail	1100°Fahrenheit (611°C) for STD & 3HB rail
800°Fahrenheit (444°C) for Chrome & Low alloy rail	1200°Fahrenheit (667°C) for Chrome & Low alloy rail

13. During the arc welding process stray electrical current can damage sensitive signalequipment.

The following is applicable:

a) Avoid accidentally striking an arc while ground clamp is attached to the opposite rail.
b) Electric grinders and slotters must be properly connected and insulation kept in good condition.
c) Location of insulated joints must be determined before any work is undertaken.
d) In locations of potential damage, notify the S & C employee well in advance in order that circuit fuses can be installed to protect the equipment.
e) All electrical equipment must be grounded at the source.
f) Multiple operator welding systems where two or more circuits are connected electrically tothe same source must not be operated.
g) No more than two single arc welding machines may be operated within the limits of anytrack circuit. This applies to territory having one or more tracks.
h) Insulation of equipment and welding and grinding cable leads must be checked at least oncea month.
i) Automatic and semi-automatic wire feed systems must be fully insulated from the unitframe.
j) All connections must be clean and tight.
k) The ground clamp must be clean, fit well, and make full contact without any current resistance.
l) During all arc welding operations, the ground clamp must be secured to the rail being welded.
m) Do not disturb the ground clamp while welding.
n) Welders equipped with mechanical ground bars must not be moved during welding, nor stopped with the ground spanning an insulated joint.

o) For the welding of insulated joints, standard splice bars shall be applied on only one joint at a time. (When the insulated joint is on the closure rail the installation of standard splice bars may short the track circuit.)

p) All bond wires must be protected against pre and post heat and welding heat, and not damaged through surface grinding and cross slotting.

q) The polarity switch must be in "OFF" position while traveling or when removing the welding machine from the track.

Chapter 10: Arc Welding in Signal Territory

Introduction

This chapter is designed to inform Railway welders that improper welding and grinding operations induce stray electrical currents into signal circuits. Stray electrical current will damage sensitive signal equipment required for the operation of trains and warning devices at public road crossings. Improperly insulated grinding equipment, push cars, motor cars, electric welding generators, etc., used by welders can short track circuits.

Shorting of signal track circuits is costly. It creates train delays; and crossing warning devices may fail to detect the presence of trains, and confusing and endangering motorists at crossings. The following explains how damages can occur.

Electrical circuits

An energized welding circuit carries high current. Normally this current travels a short distance from the machine through the work and back to the machine. However, in the event that the current cannot return through the normal path it will seek a path through track connections and into the signal circuits.

By comparison, the components of a signal circuit are more delicate and electrically sensitive than those in a welding operation. The welding operation utilizes electrical power in the hundreds of ampere ranges while a signal circuit may operate at .150 amperes at 2 volts; therefore, sensitive signal equipment will be damaged or destroyed.

Damage to signal circuits

The electrical or electronic components that form the signal circuit will be damaged or destroyed when a welding arc is accidentally struck on a rail while the ground clamp is attached to the opposite rail or across a joint. This can establish a path through the signal circuits that are connected to the two rails. The current will flow through the series of relays, resistors, etc. melting them, resulting in a malfunction.

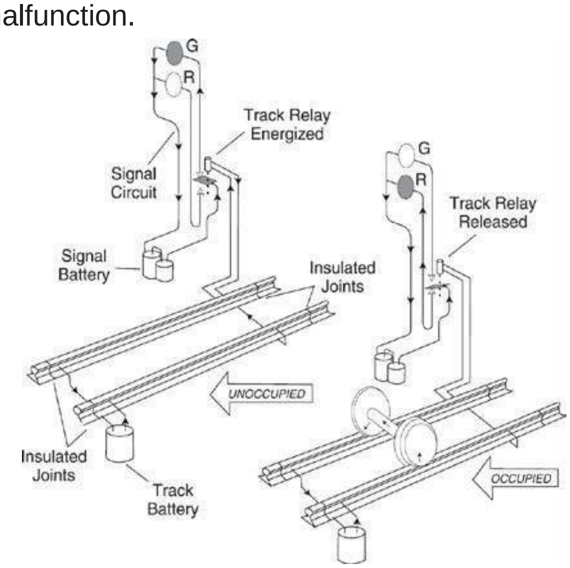


Figure 10.1- Trackcircuits

Electric grinders can also cause damage to signal circuits if improperly connected or if the insulation is not kept in good condition. Should the insulation break down, it can shunt a track circuit or the high voltage used to power the grinder can flow into the signal circuits.

Instructions

To prevent problems for the Railway welder, the Signal & Communications people and the overall operation of trains and crossing warning devices, the following instructions must be observed while electric arc welding and operating electric grinders on the track.

The requirements of GO Transit Track Standards section 7 Field Welding as well as any other applicable rules must be carried out. Except in case of emergency, Foremen must obtain advance permission from the train dispatcher and advise the S & C Maintainer before commencing any track-work that will interfere with the signal system.

All personnel must observe the adjacent signal and highway warning devices. If an abnormal condition affecting traffic is observed, immediate action must be taken to protect the traffic, whether by rail or public road, and advise the proper authorities of the abnormal condition.

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, then prior to commencement of work the S & C Maintainer must identify those limits and how the welding equipment can be connected and used to prevent signal circuit damage. For the welding of insulated joints, (other than glued or Bonded Insulated), standard splice bars shall be applied on one joint at a time.

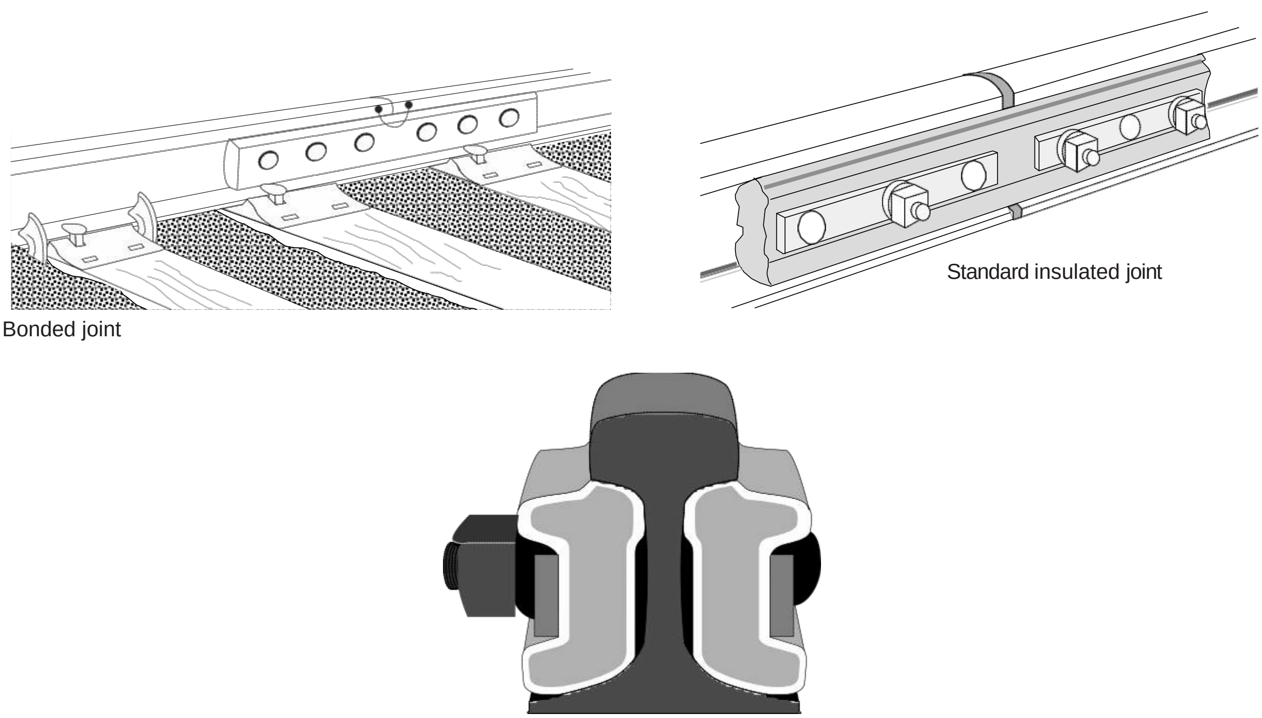


Figure 10.2

All electrical equipment must be grounded at the source.

No more than two single arc welding machines may be operated within the limits of any track circuit. This applies to territory having one, two, three or more tracks.

The insulation in welding and grinding equipment must be checked frequently. Defective cables, connectors, sleeves, ground clamps and electrode holders must be replaced immediately. All connections must be clean, tight, well fitting, and make full contact.

Figure 10.3 –Bosch 9 inch handheld grinder

Automatic, and semi-automatic, wire feed systems must be fully insulated from the unit frame. Grind-off oily and rusty metal surface to ensure that the ground clamp makes full contact without excessive electrical resistance. The magnet type grounding device for out of face welding must be applied on a clean surface of the rail head as close as possible to the work being done.

During all arc welding operations, the ground clamp must be secured to the rail being welded. Do not remove or otherwise disturb the ground clamp while welding is in progress.

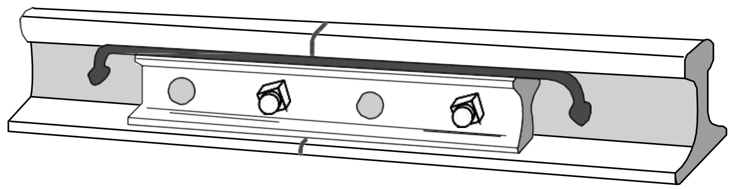
Electric welders equipped with a mechanical ground bar must not be moved during welding nor stopped with the ground spanning an insulated joint. On-track grinding equipment must not be left spanning, or with a wheel standing on an insulated joint.

Crews involved in welding switch points, frogs, diamonds, etc. must use only fully insulated electrode holders (i.e., “short stub”). If the welding operation is interrupted to allow for the passage of rail traffic, the electrode must be removed from the holder.

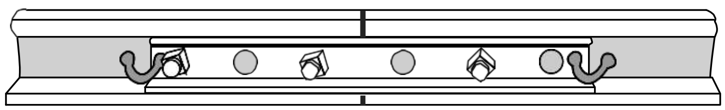
Bonds

Bonds or bond wires are used to maintain an electrical path for signal circuits. All bonding wires must be protected against pre heat, post heat and welding heat. They must not be damaged through surface grinding or cross slotting.

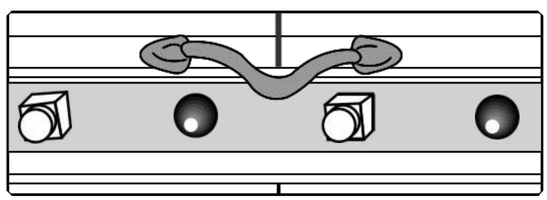
Bond wires are made up of many strands of wire rather than one solid wire. The flexibility is necessaryto eliminate bond breakage due to vibration and rail motion caused by trains running over bonded rail joints. There are many different types of bond wires in use, several types and methods of applying them are illustrated below. Cad-welds may also be used for rail bonds provided, the rail joint is a permit rail joint, and not a temporary rail joint that is to be removed by field thermite welding.



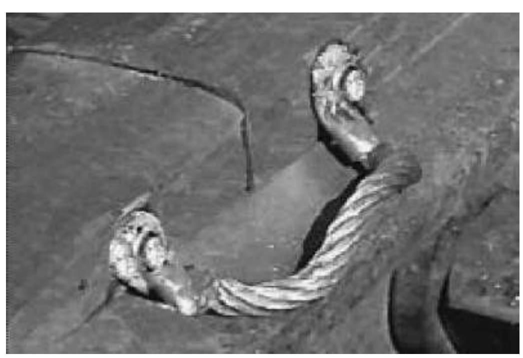
Rail web connection



Rail web to angle barconnection



Rail head connection



Pin-brazing

Figure10.4-Signalbonds

Precautions

S & C Maintainers will carefully observe conditions while welding is performed on their territory. They may report any practice that in their opinion endangers the proper operation of the Signal Apparatus and/or discuss corrective action with the Welder. On all welding and grinding equipment, each track wheel shall be insulated individually. Use care while welding insulated turnouts. Gauge plates in the switch point area are insulated. An arc struck accidentally on the rail or track component not properly grounded will cause the high welding current to flow into the signal circuits.

The welding ground must be located on the same unit (rail, etc.) that is being welded.

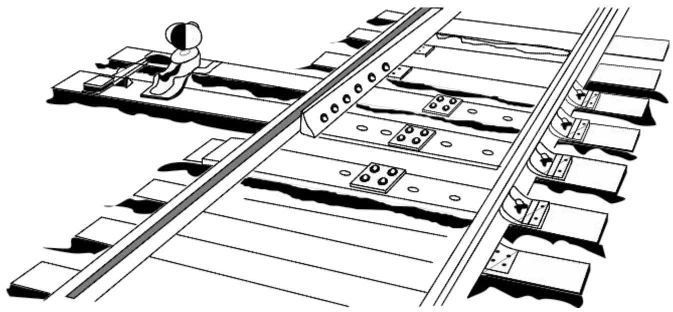


Figure 10.5 - - Gauge plates showing insulation

Use extreme care and learn to recognize the potential dangers involved when operating electric arc welding and grinding equipment.

When arc welding, precautions must be taken not to damage signal installations through short circuits or introducing high welding current into signal circuits.

Damage could occur at wayside inspection systems, (hot box and dragging equipment detectors) if, the instructions are not adhered to. The transducers and scanners will malfunction if over-heated by welding or the introduction of stray electrical currents. If damaged, the systems give false reports and stop trains for unnecessary inspections delaying traffic.

Use all precautions necessary to protect yourself, your fellow employees and electrically sensitive signal equipment. The life you save may be your own. The signal equipment you protect may save someone else's life.

Chapter 11: Carbon Steel Rigid Frog- Welding

Introduction

The common rigid rail frog is utilized in yards, spur lines and sidings but never on high-speed main line tracks. Constant wheel pounding results in progressive metal flow and wear. Even when chipped or worn to the maximum allowable tolerance of 10mm (3/8"), these frogs may be refurbished using the electric-arc welding method.

Inspection andpreparation

Before work is begun, an inspection and correction of track conditions should be made in accordance with GO Transit Track Standards. Any buildup of grease should be scraped off. In winter conditions the removal of snow or ice may be required as well to properly inspect the condition of the frog. The frog can then be closely examined to determine whether it is repairable in track or not. Determine the depth and length of wear with an approved straight edge and mark extremities with a soap stone marker.

Defective metal may be removed by grinding.

Unless protection is otherwise provided for by Canadian Rail Operating Rules (C.R.O.R.), care must be taken not to remove too much metal so as to render the frog unsafe for traffic. If size, depth or severity is extensive enough, it may be necessary for the defective frog to be removed and re-welded in stages or scrapped.

Required PPE must be in place before starting the machine. Proper wheel guards must be in place and properly adjusted per ANSI code. Guards are not to be removed oraltered.

Preheating

Rail steel is a high carbon steel, and rapid cooling from the arc welding temperature can produce a hard, brittle zone adjacent to the weld.

This difference in temperature in close proximity to the weld area causes a quenching action, which results in a zone affected by thermal shock and stress.

In track, under wheel impact, this condition will cause under bead cracking and consequent failure. To prevent thermal shock, any portion of the rail steel, which will be affected by welding must be maintained at 700°F (389°C) during welding. This is done by the use of a special propane heater (Figure 9-1).

A 700°F (389°C) temperature crayon or approved device must be used to ascertain that theproper temperature is maintained. When heating in the area of the weld limits, one of the heater blocks should be placed so that it heats 100 - 150mm (4"-6") beyond the weld limit to ensure that thermal shock does not occur.

Pre-heating beyond 700°F (389°C) is detrimental to the welding process; therefore, as soon asthe correct preheat temperature has been reached, welding should commence.

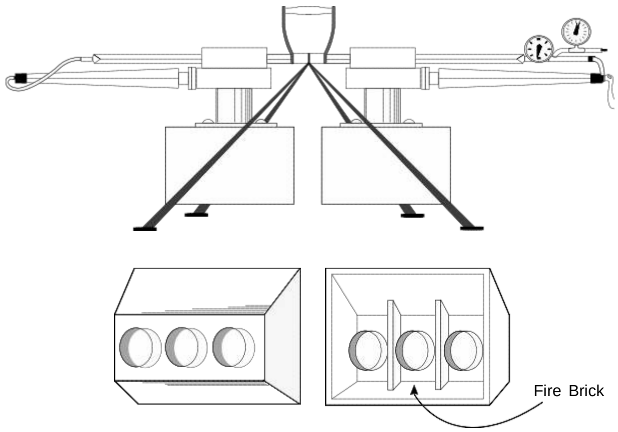


Figure 11.1 - Propane heater

Welding procedure electric arc

Only approved electrodes may be used in rigid frog welding. The buildup should be started on a wing, (if point was damaged, most of the time one of the two wings is damaged also) about even with the point end. The first bead should be along the flange-way moving toward the heel. The point buildup should be started at the point end and progressed toward the heel with an appropriate easement.

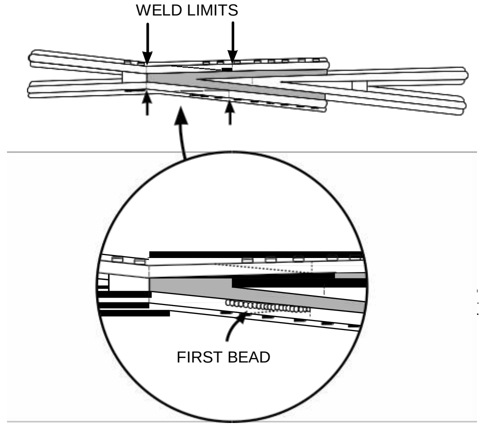


Figure 11.2

The electrode should be deposited in a weave pattern, which will result in a bead about 13mm (1/2") wide. The arc should be kept tight. Before breaking the arc, fill the crater puddle so the entire deposit is of uniform height.

All flux and slag must be removed before an adjoining bead can be deposited. Due to the rapid heat loss and danger of thermal shock, the point should be welded last. By that time, the surrounding castings should be warm and provide some heat retention.

Post heating

After the welded portion has cooled to 700°F (389°C) or less, the weld heat affected zone must be post-heated to 1100°F (611°C). The temperature should be raised uniformly and a second set of heaters should be used if available to provide a soaking heat.

Post-heating serves two main purposes:

1. To remove the residual stresses and thereby prevent cold cracking.
2. To normalize the heat affected zone and provide a uniform hardness ranging between 340 and 380 Brinell points.

If post-heating is carried out during cold, wet, or windy weather, heat retaining blankets must be used.

Finish grinding

Both point and wing rail should be the full height and of proper contour with the exception that the tip of the point should be 5mm (3/16") lower than the wing rails, tapering back to level, one half the number of the frog. For these types of frogs the same formula is applied for the detail of the point. (e.g., No. 8÷2 = 4" or No. 12÷2 = 6")

The flange-ways must provide standard 48mm (1-7/8") clearance, be straight and smooth, with the top corners rounded to 10mm (3/8") radius.

All easements must be finished so that any variance in height is feathered out to provide a smooth wheel transfer.

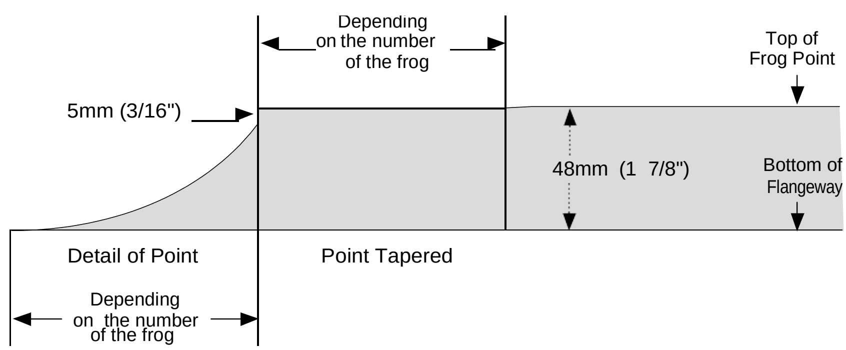


Figure 11.3 - Detail of point

On completion of surface grinding, the heel and toe joints should be slotted.

A groove 5mm (3/16") deep and 3mm (1/8") wide should be cut between the long and short points, as well as between the wings and the easer rails. All grinding dust should be removed. Finally, the frog and the guard rails should be oiled with, environmental friendly oil, the bolt tension checked, and any broken or missing washers replaced.

Out of track, frogwelding

Frogs may be welded successfully out of track by the same procedure, providing a suitable stand is built to support the frog off the ground. A means must be provided also whereby the frog can be pulled down at each end to overcome distortion and to straighten the frog if it is service bent.

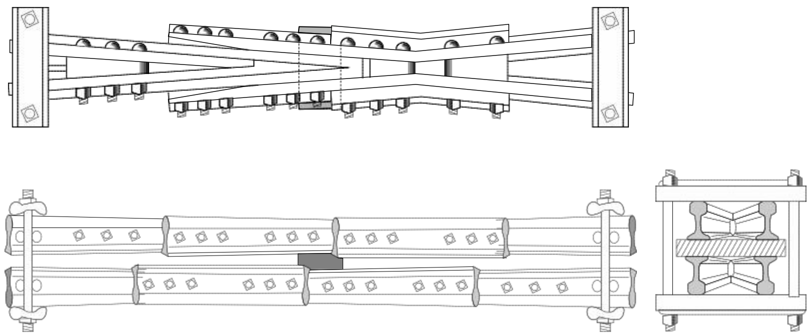


Figure 11.4 – Frog welding out of track

Review

The following is intended to highlight the more important aspects of carbon steel rigid rail frog welding.

- Inspection and preparation of the frog prior to welding.
- The importance of preheating - electric arc.
- The procedure for welding by electric arc and post heating.
- Finish grinding of the welded frog.
- Out oftrack.

Chapter 12: Spring Frog Welding -Electric-Arc

Introduction

Periodic building up, by welding of the spring frog wheel transfer section, assists in obtaining maximum life of the frog and helps prevent premature retirement.

Notes:

a) Only welders certified by a Welding Supervisor may weld spring frogs.

b) Chrome and alloy rail and parts thereof are to be welded by electric-arc only.

c) The electric-arc method is the faster and longer lasting process.

Spring frog conditions must be checked regularly and repairs made as soon as or shortly before wear tolerances reach the following limits:

1. Point Wear:
   a) Maximum allowable point-wear: 5mm (3/16”).

      Measurement is taken where the first sign of double flange wheel contact is evident on the movable wing toward the heel.

   b) Maximum allowable point-wear: 10mm (3/8”).

      Measurement taken 200mm (8”) back from pointend.
2. Vertical movement of spring wing:

   Maximum allowable combined clearance between the top and the bottom of horn and hold down housing is 6mm (1/4”). Minimum clearance is 3mm (1/8”).

Notes:

Base of spring wing must rest on the base plate for its full length when measurements are taken.

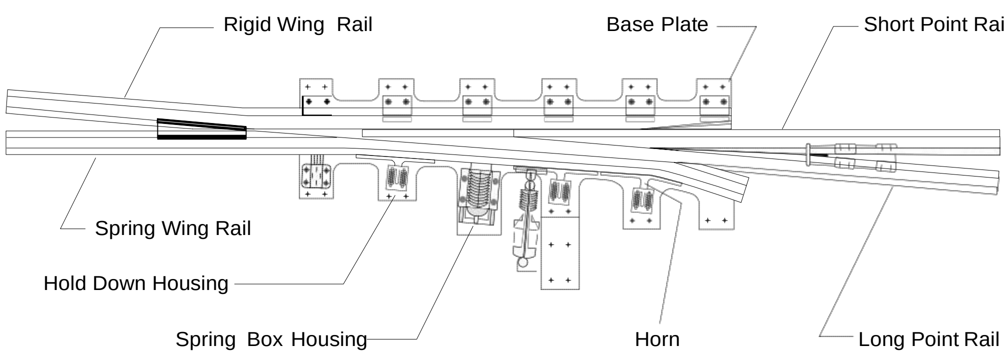


Figure12.1– Typical,No.12 -136#springfrog

Preparation

a) Provide adequate protection as prescribed by the rules before the work commences.

b) Scrape or burn off any grease build-up and inspect for cracked or broken components suchas braces, base-stops or hold down housings. Before welding on the running surface defective parts must be repaired or replaced. Winter conditions may require the removal of snow or ice, that will allow the proper inspection ofthecomponents.

c) Ensure proper surface and alignment and tighten all bolts replacing any broken ormissing washers.

d) Weld and grind to level any mismatch in heel and toe joints.

e) Remove any defective metal by grinding. Do not remove so much metal so as to renderthe frog unsafe for traffic. Grind and re-weld in stages if necessary.

Electric arc procedure

1. Propane fuel is required for preheat because it provides a deep or "soaking" heat.

   Preheat the weld area and at least 200mm (8") beyond the weld limits to 700°F (389°C). Preheat chrome and low allow head hardened to 800°F (444°C) up to 250mm (10") beyond the weld limits. Heat the casting or reinforcing stock as necessary so that preheat temperature is not robbed from the weld zone. Welding must commence as soon as the preheat temperature has been reached. Be certain to maintain the preheat temperature as welding progresses, stop to check periodically.

2. The frog point must be welded first when work begins on the wheel transfer section. If the spring rail were to be welded first and it became necessary to pass a train through the work area, it is possible a false flange on a wheel would pry the wing open and then drop between the spring wing and rigid wing ahead of the point.

   Begin welding at the thin point end using appropriate approved electrodes. Complete 150mm (6") per pass in a heavy weave pattern resulting in a bead about 13mm (1/2") wide. (Warning: Do not use stringer beads.) All slag must be removed before an adjoining bead is deposited. Build each 150mm (6") section to desired height before moving on to the next. Weld height must allow for finishing the top of the rigid wing from point end radius to the end of the channeling in the movable wing. Then a gentle easement must beprovided.

   If train protection is absolutely assured, or frog has been removed from track, sections as large as 250mm (10") may be completed per pass.

3. When the point has been rebuilt, jack the spring wing open and post-heat the entire welded area on the point to 1100°F (611°C) for Standard or Hi Si rail and for chrome and alloy rail to 1200°F (667°C). Use only approved heat source for post-heating. With the wing open,grind any excess metal from the side of the point so that when the jack is removed the spring wing fits tight against the point.

   Note:

   The spring wing rails of 115 lbs. and larger spring frogs have two knees and are designed to be open 10mm (3/8") at the half inch point.

4. Do not induce cooling. On cold or windy days, cover the weld area with a heat retarding blanket.

5. The next step is to weld the spring wing using the same basic procedures as for the point, except that to control distortion, heat must be opposed to the outside of the base fillet on completion of each 150mm (6”) welded section. Heat with an oxyacetylene flame (No. 70 tip) to a dull red. Do not move the torch rapidly but allow for a soaking heat build-up. Sudden heat input, followed by quick quenching will cause martensite. This must not be confused with preheating or post-heating techniques.
6. When the weld has cooled to 700°F (389°C), jack the spring wing open and post-heat the weld area as required. Grind as necessary, then remove the jack and allow to slowly cool-down by the use of heat retarding blankets.
7. The same welding procedure is followed on the rigid wing.
8. Finish grinding the entire frog to contour and slot as required.
9. Do not leave the frog until complete cool out. Ensure proper fit of wing rail against point rail and base plate without distortion.

Note:

Placing the jack immediately over the spring box will help prevent distortion of the spring wing.

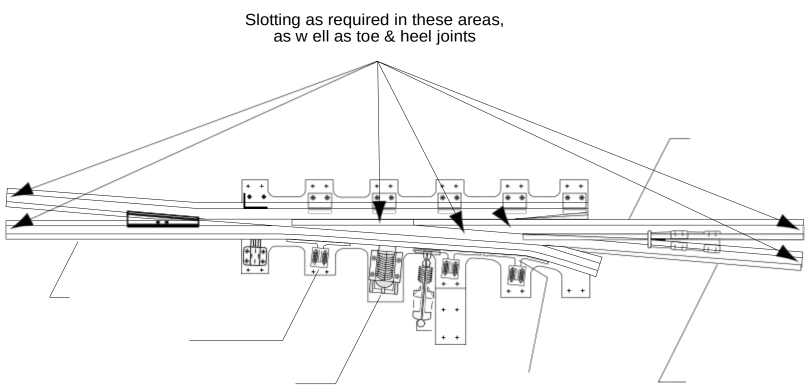


Figure 12.2

Hold down housings

With the spring wing resting fully on the base plates, the clearance between a horn and hold down housing must not have less than 3mm (1/8”). If the clearance is found to be in excess of 6mm (1/4”), the hold down housing must be replaced.

Final inspection

1. Bolts must be checked and tightened as required and properly lubricated.
2. Spring wing rail must fit properly against the point and flat on the base plate for its entire length. Lubricate the base plate.
3. Spring must have proper tension.
4. Spring wing travel should be 47mm (1 7/8”) at the1/2” point. Measurement is taken at gauge line when the wing is jacked open to its stops. Opening between spring wing rail and point rail must not be less than 45mm (1 3/4”) at any location.

Preventive measures

1) When working on live track operating any equipment, it is essential that one employee act as a dedicated lookout, this is known as the "Watchperson/Lookout."
2) The dedicated lookout person must never engage in other tasks, which could interfere with the responsibility of protecting others, but must watch for oncoming hazards in all directions.
3) The proper eye protection is required to prevent arc flashes. The minimum color grade is welder's green 3 but 5 is preferable.

Remember:

The safety watch – is a watch forlife!

Chapter 13: Switch Point Welding

Introduction

No welding of switch points or stock rails on class 3 track and above. With the following exception: In cases of emergency. Welding will be allowed, following proper welding procedures and limiting the speed over the weld repair area to class 2 track (25/30) until component is replaced.

The first and most important factor the welder must consider in switch point welding is safety. All precautions as outlined in GO Transit Track Standards section 12 Installation and Maintenance of Turnouts and other applicable standards must be followed.

During the entire operation, the welder must ensure that the switch is safe for normal traffic movement at any time or protection provided accordingly.

The welder must work in close co-operation with dispatchers or controllers, arranging for enough time to complete the welding and grinding work on the switch point. When working in signal territory a Signal Maintainer must be present when work is performed, and for final signal adjustments.

A second important factor is the pre-inspection of the turnout. Refer to chapter 2 regarding turnout pre-weld requirements.

On arrival at the turnout, the welder must ensure that any pre-weld work has been completed, such as bolts tightened, ties tamped and the point straight and fitting against the stock rail for the full distance of both top and bottom planed surfaces.

If the switch point is bent, it should be straightened prior to welding. For standard and Hi Si points use the procedure described in chapter 8 Distortion in Track-Welding. The switch point must be straight and rest easily and evenly on all of the riser plates. Bent switch rods and connecting rods must be straightened.

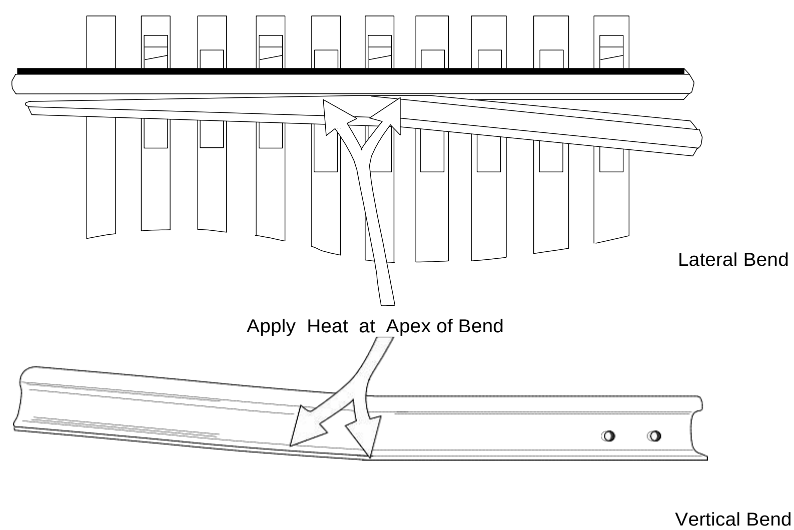


Figure 13.1

Before applying any heat the welder must determine the type of steel in the switch point. Standard carbon and Hi Si points and 3HB can be welded by oxyacetylene or electric-arc methods. All other points are to be heated with the T8 turbo torch or special switch point heater using propane fuel and welded by the electric-arc process only.

Before welding a switch point make sure the overflow on the stock rail and the switch point is removed along the entire length of the mating surfaces. This must be done by using a stock rail grinder or hand held grinding head and taking care to remove the flowed metal only. Particular care in this respect must be exercised when grinding Samson type points and stock rails.

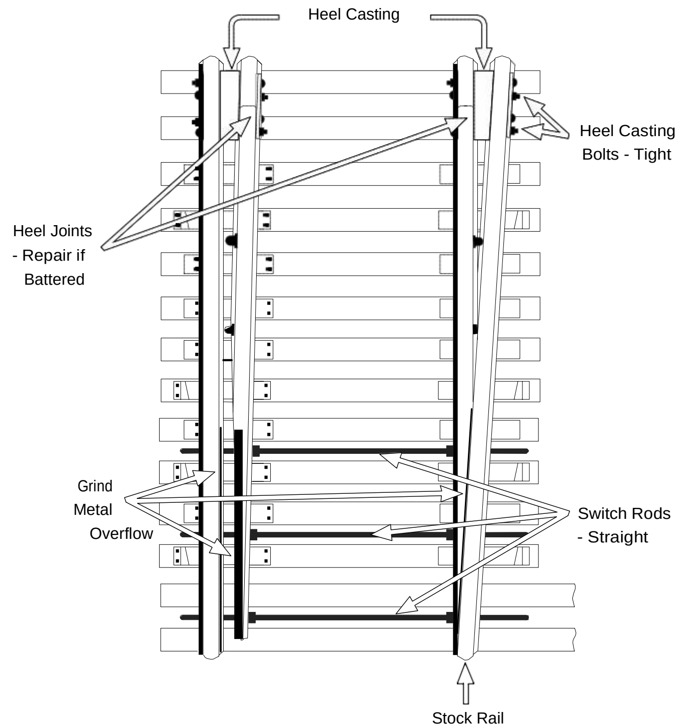


Figure 13.2

With all the preliminary work completed, the welder is now ready to start welding.

Controlling distortion in switch point

Controlling contraction of the switch point during welding is done by applying heat of approximately 750°F (417°C) at the base fillet of the switch point for each section welded.

Great care should be exercised to concentrate the heat on the base fillet. Keep the concentration of heat away from the outer edge of the base. Too much heat reaching the outer edge of the base can cause the point to warp sideways and away from the stock rail. If this happens, the stock rail side of the switch point should be quickly heated for 300mm (12") first along the side of the head, then correspondingly along the base side.

The principle of contraction should be well understood because of its value in controlling distortion as well as correcting it, whether caused by welding, heating or mechanical means.

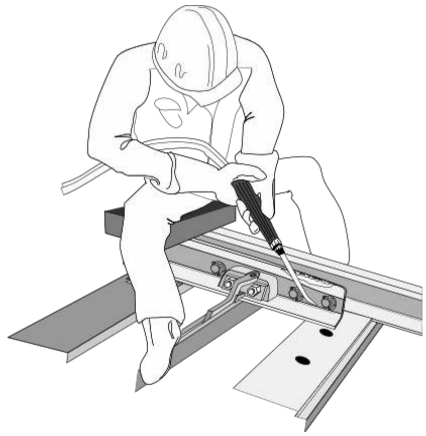
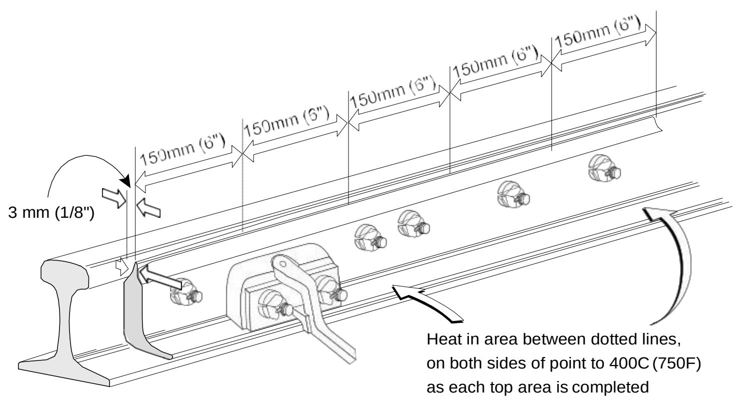


Figure 13.3 – Controlling distortion at the base fillet



The welded switch point must not be left unattended until it is certain that all contraction stresses have stopped and the switch point is seated and is closing properly.

Electric arc method

Switch points constructed from all rail types may be welded by the electric arc method. Follow the same procedures as outlined in Appendix B of this chapter as well as the following below:

Ascertain the rail type and thereby the procedure for the repair. Ensure that the correct materials are on hand and that conditions are favorable (weather, track, etc.). All defects, such as those heavily battered, deformed, spalled or cracked material must be removed by grinding prior to welding. Under no circumstance may acetylene cutting torches be used. The area ground out must provide a flat, smooth surface on which to weld.

Preheat temperature is 800°F (444°C) for chrome alloy, 800°F (444°C) for low alloy head hardened and 700°F (389°C) for all other rail chemistries. Heat must be applied by a special switch point heater or the T8 Turbo torch. Bars or reinforcing straps should also be preheated to the prescribed temperature as the material in close contact with the switch point being welded may act as a heat sink.

Preheat and inter-pass temperatures are particularly important and should be checked with temperature indicating crayons during welding.

Care must be taken to apply a slow, gradually soaking preheat. Preheat temperatures should be maintained throughout the welding operation. Areas that require considerable build-up, and after traffic interruption may call for repeated application of heat, especially in windy or cold weather.

Care must be taken to avoid overheating during preheat. In no instance should the local preheat exceed the stated minimum by more than 300°F(167°C).

Aids to welding

A copper plate between the switch point and stock rail serves as a back-up for the weld deposit and is held in place similarly to a forging block (note that a carbon block used in austenitic manganese repair cannot be used because there can be deposits left in the rail). The arc bead applied to the steel switch point will fuse with the steel, but not the copper. It also protects the stock rail from heat damage resulting from the arc weld. The copper plate should be approximately 25mm x 50mm x 600mm (1/4" to 1" x 2" x 24").

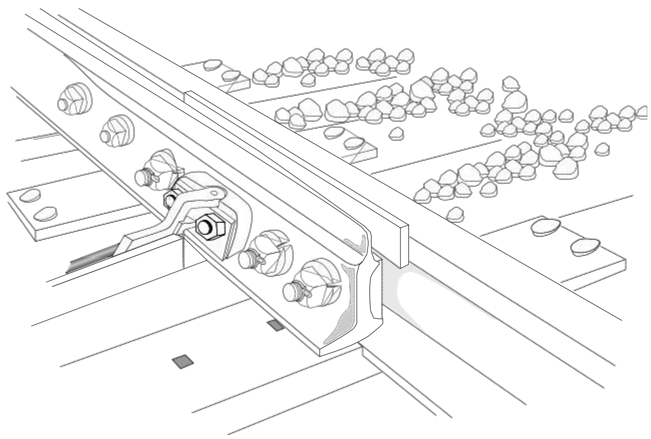


Figure 13.4 - Copper plate inserted between switch point and stock rail

If the point is worn thin, apply horizontal beads along the gauge side of the point just below the ground out surface to provide a wider surface to weld on.

Success of welding repairs depends largely on control of the weld cooling rate. Keep the weld area free from snow and moisture. Welding must not be carried out in heavy rain or falling and drifting snow. A shield must be erected to protect the work area from wind.

As with oxyacetylene welding, after arc welding of the first 150mm (6") to the required dimensions, the remaining sections in turn can be welded. Preheat must be maintained. Weld beads must be cleaned after each pass, and all slag removed by chipping or wire brushing. If slag is trapped in a weld, or if any defects occur, they must be removed by grinding before welding continues. Immediately after chipping and, while the weld deposit is still hot, peen the weld beads lightly to relieve stress. Post-heat each completed weld section as required. Grinding to finish dimensions follows completion of the welding operation.

Protection

Again, it must be stressed it is essential that the work zone be protected from wind and draughts, which may destroy the gas shield when welding and produce an inferior weld.

Post heating

On completion of welding, the entire weld deposit plus the heat affected zone must be post heated, chrome to 1200°F (667°C), all other rail chemistries to 1100°F (611°C). A soaking heat from propane heater must be applied similarly to the method of preheating. After post-heating it is essential to control the cooling rate of the heat affected zone to avoid the formation of martensite (a hard brittle structure). Standard and Hi Si points must be covered by a heat retarding blanket during any precipitation or freezing temperatures. In all instances, chrome alloy and low alloy head hardened points must be covered.

The cooling rate of chrome and low alloy and steels with self-hardening properties must not exceed:

- .9°F (.5°C) per second between 1472°F (817°C) and 752°F (418°C)
- 4.5°F (2.5°C) per second between 752°F (418°C) and 392°F (218°C)

Notes:

Switch points can be successfully welded in the field and should only be welded by fully qualified personnel, working under full protection under the Rules applicable on the subdivision on which the work is being done. Extreme caution is to be used.

Switch points should not be welded beyond the tapered planed section and can be done more than once.

No movement of trains should be permitted over welded points until heat in the affected zone is below 400°F (222°C) and there is no further contraction.

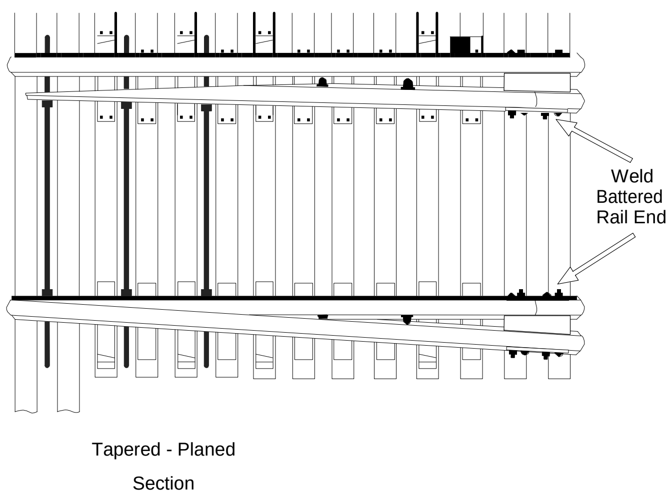


Figure 13.5 - Tapered- planed section

On cool out, use approved graphite, oil or grease must be applied to the heat affected areas of switch point, stock rail and plates in order to provide easy throw and retard the formation of rust.

Appendix 2

Welding Switch Points

1. This circular covers regulations, preparations and procedures for repair of switch points by oxyacetylene and by electric arc processes, when they are permitted.
2. Regulations:
   a) During the entire operation, the switch must be safe for normal traffic movement or protection provided. Traffic should not be allowed until temperature at repair area is below 392°F (218°C).
   b) GO Transit Track Standards section 12 Installation and Maintenance of Turnouts and other precautionary measures specific to the location must be observed to avoid interference with the Signals and Communications systems..
   c) Only welders qualified by the supervisor may weld switch points in track.
   d) Only welding materials approved by the Senior Manager of Track & Structures for switch point welding may be used.
   e) Welding of manganese tip switch points is prohibited.
   f) A welded switch must not be left unattended until all contraction has stopped and it is certain that the point seats and closes properly.
3. Preparations:
   a) Prior to welding, the reason for the breakage, or any unreasonable wear that could lead to premature breakdown, must be determined and corrected.
   b) The switch point should be straight and well adjusted, and should fit against the stock rail for the full distance of both top and bottom planed surfaces.
   c) Overflow on the field side of the switch point and the adjoining gauge side of the stock rail must be removed and top radius restored.
4. Procedure - Arc Welding
   a) All heavily deformed, spalled or cracked material must be removed in stages by grinding prior to welding.
   b) The electrode used must be in the same hardness range as the switch point.
   c) The repair area to be built up and adjoining reinforcing straps must be pre-heated to 752°F (418°C). Heat must be applied and maintained using a propane heater. In no circumstance may oxyacetylene be used for heating of a chrome alloy or low alloy head hardened switch point.
   d) To control the shape of the weld deposit during build-up, a non-ferrous bar is to be applied along the top field side planed surface.
   e) The weld must be started at the point end and progressed in stages of 100 to 150 mm (4 to 6") toward the field end.
   f) Point end thickness at gauge line must be restored to 3mm (1/8").
   g) "As new" contour from point end throughout the area being repaired must be maintained and then feathered out. This is accomplished by grinding the weldment to a smooth finish.

h) (Post-heat). On completion of welding, the entire weld heat affected zone must be post-heated to 1200°F (667°C). For chrome LAHH and for all other alloys it is 1100° F (611°C). A soaking heat must be applied similar to the method of pre-heating.

i) After post-heat the cooling rate must be controlled until the point has cooled to 392°F (218°C). Standard rail points must be covered by a heat retarding blanket during any precipitation or freezing temperatures. IN ALL INSTANCES, CHROME ALLOY AND LOW ALLOY HEAD HARDENED POINTS MUST BE COVERED BY A HEAT RETARDING BLANKET.

j) On cool out, use approved graphite, oil or grease must be applied to the heat affected areas of switch point, stock rail and plates in order to provide easy throw.

Chapter 14: Stock Rail Welding & Engine Burn Repair

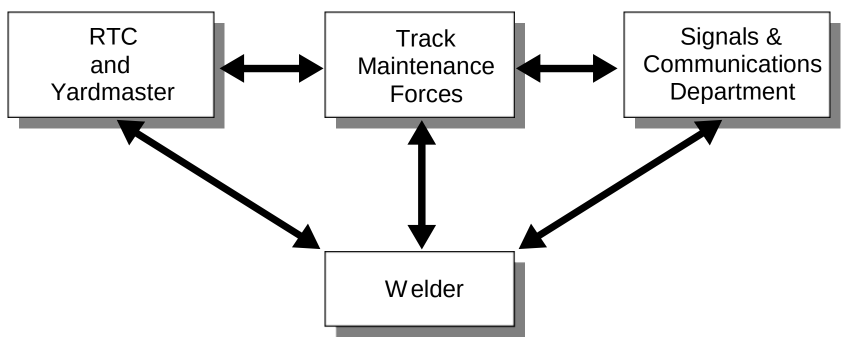
Stock rail welding

Introduction

The first and most important factor the welder must consider in Stock Rail Welding is **SAFETY**. Stock rails can only be repaired in Class 1 and class 2 tracks.

During the entire operation the welder must ensure that the switch is safe for normal traffic movement at any time or **protection** provided accordingly.

The welder must work in close co-operation with dispatchers or controllers, arranging for enough time to complete the welding and grinding work on the Stock Rail. When working in signal territory a Signals & Communications Maintainer must be present when work is performed, and for final signal adjustments.



Co-operation = 2 Way Communications

Figure 14.1

Stock rail, wearconditions

The greater amount of stock rail wear is concentrated in the area along the switch point where:

1 The wheels change direction entering the switch (Figure14-2a).

2. Wheels with double flanges, angle across the stockrail (Figure 14-2b).

3. Wheels descend from the higher elevation of the switch point. (Figure 14-2c)

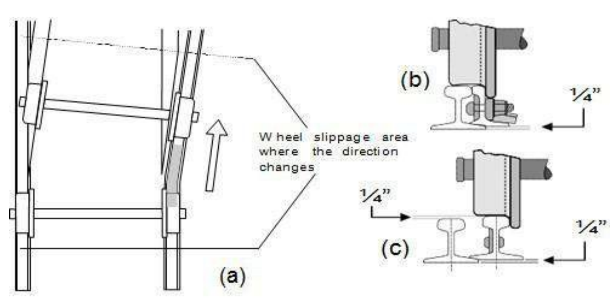


Figure 14.2

When a depression has started, the progression in length and depth escalates exponentially (progressively), eventually causing removal of the stock rail. The top surface of the switch points must be installed 6.4mm (1/4 inch) higher than the stock rail as shown on Standard Plan. When this dimension is reduced by wear to a minimum of 4.8mm (3/16 inch), the stock rail and/or the switch point must be renewed to restore the 6.4mm (1/4 inch) dimension. By rebuilding the worn section of the stock rail in the early stages of wear, obvious benefits can be realized.

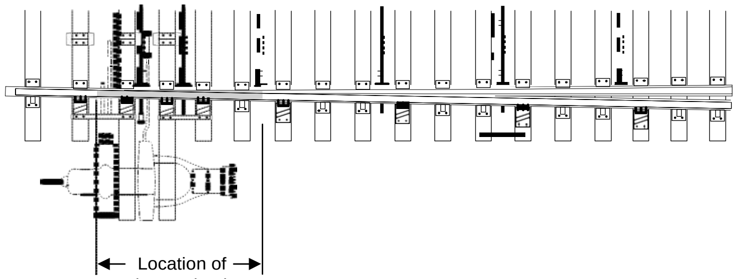


Figure 14.3

Pre-inspection ofturnout

An important factor is the pre-inspection of the turnout. Refer to chapter 2, regarding turnout pre-weld requirements.

On arrival at the turnout, the welder must check the switch and ensure that any pre-weld work has been completed, such as:

a) Bolts tightened

b) Ties tamped and switch area surfaced.

c) Switch point straight and fitting against the stock rail for the full distance of both side and bottom planed surfaces.

d) Metallurgy of the stock rail and mated switch point are known.

Stock rail weldingpreparation

1. Do not undertake welding of chrome and LAHH (Low Alloy Head Hardened) stock rails during rain or snow conditions or when the rail temperature is below 32° F or above 83°F (0°C or above 30°C).
2. If the switch point is bent, it should be straightened prior to welding the stock rail. For standard and Hi Si points use the procedure described in Chapter 8: “Distortion in Weld Welding”. The switch point must be straight and rest easily and evenly on all of the riser plates. Bent switch rods and connecting rods must be straightened.
3. The preferred length of repair to the stock rail by welding is from 305mm to 381mm (12” to 15”). The maximum length of repair, permitted is 762 mm (30”). Do not attempt to repair batter that is deeper than 9.5 mm (3/8”). If deeper, the stock rail must bereplaced.
4. Before applying any heat, the welder must determine the type of steel in the stock rail. Standard carbon, Hi Si and 3HB rails can be welded by electric-arc method. All other rails must be pre-heated and welded by the electric-arc process only.

5. Before welding a stock rail make sure the overflow on the stock rail and the switch point is removed along the entire length of the mating surfaces. This must be done by using a stock rail grinder or hand held grinding head, taking care to remove the flowed metal only. As excessive grinding will require additional welding to restore the rail to original contour.

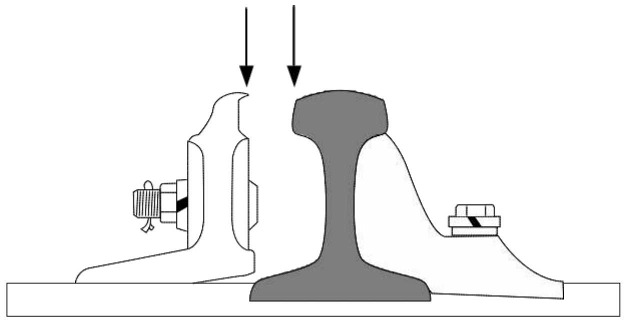


Figure 14.4

6. All defects, such as those heavily battered, deformed, spalled or cracked material must be removed by grinding prior to welding. If defects such as cracks extending into parent metal are found, no effort is to be made to fuse the defective metal to the base metal. Grind the cracks out to sound metal.
7. Under no circumstance, may acetylene cutting torches be used. The area ground out must provide a flat, smooth surface on which to weld.
8. Crown the repair area with a jack and install a (3 ea.) 6.4 mm (1/4") shim under the center location. Remove each 1/4" shim as it cools out after post-heating. 1 at 800°F (444°C), 1 at 500°F (277°C), and so on.
9. Pandrol clips at the repair area should be removed, if necessary.

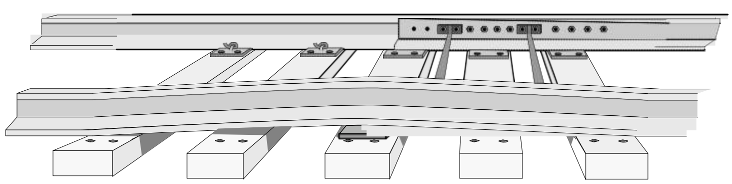


Figure 14.5

10. Rail braces must be removed prior to pre-heating since they act as a heat sink during pre-heating and cooling causing hardening of weld area resulting in potential breaks. The brace hole (threaded) should be filled with grease to prevent arc splatter from sticking to threads.
11. With all the preliminary work completed, the welder is now ready to start welding.
12. Use only 4.8mm rod for welding to help the control of distortion.

Remember:

Determine the rail type and thereby the procedure for the repair. Ensure that the correct materials are on hand and that conditions are favorable (weather, track, etc.).

Stock rail welding procedure

1. Use either a SECEMM, or a Rex-O-Therm or other approved propane heater to slowly preheat the first section. Preheat Standard, Hi Si and 3HB rails to 700°F (389°C). Chrome alloy rail is to be heated to 750°F (417°C). Low alloy head hardened rail is to be heated to 800°F (444°C). To overcome distortion, preheat should be applied at both sides of base-web fillet and both sides of rail head.

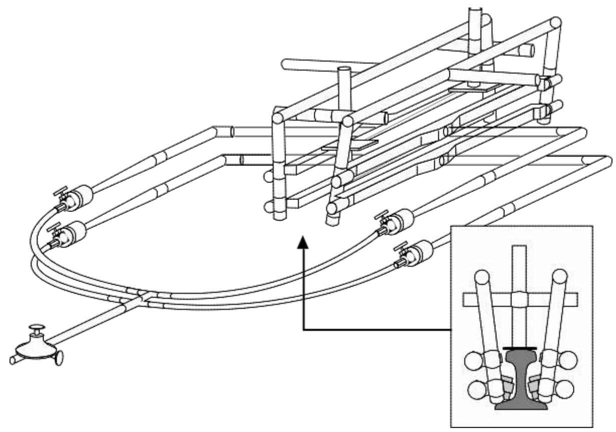


Figure 14.6

2. Preheat and welding inter-pass temperatures are particularly important and should be checked frequently with an accurate, approved "Digital Thermometer" during the welding operations.
3. Care must be taken to apply a slow, gradually soaking preheat. Preheat temperatures must be maintained throughout the welding operation. Areas that require considerable build-up, may require, additional application of heat after an interruption, especially in windy or cold weather.
4. Care must be taken to avoid overheating during preheat. In no instance should thelocal preheat exceed the stated minimum by more than 302°F(168°C).
5. Only the approved electrode/wire shall be used for repair for the specific rail type. Set the (DC) welding machine within the Amperage range of 225 to 275. Electrode positive polarity (reverse polarity).
6. Start applying the weld deposit on the buildup area nearest to the bend of the stock rail in the center of the rail head, working along the axis of the rail. To minimize distortion the next bead should be along the first bead but on the field side. Then fill in the gauge side. Then on the gauge side and alternate passes if more than three (3) beads are needed to cover the top of rail.The length of welding passes depends on width of beads and size of electrode used. At no time shall a complete pass be welded over 10" at one time.
7. Bead patterns must be slowly progressing either crescent or weave and with a (laid down)tight arc.

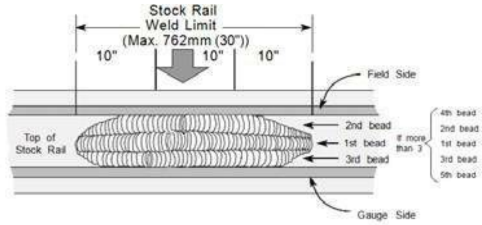


Figure 14.7

8. Starts and finishes must be staggered across the rail head. Welding Inter-pass temperatures must be controlled and maintained at that of the preheat temperature. As slag is removed the beads should be lightly peened to relieve shrinkage stress (distortion). After each 10” the blanket should be put over and next section preheated, and so on.
9. After the weld has cooled to below 700°F (389°C), post heat it in a manner similar to preheat ensuring a balanced heat in both directions:

   2” beyond the weld area for 1100°F (611°C) for Standard, Hi Si, 3HB

   10” beyond the weld area for 1200°F (667°C) for chrome and LAHH
10. To ensure slow cooling, an insulating refractory ceramic fiber blanket must be used to cover the post heated area. The blanket must be left in place for at least 15 minutes. Chrome alloy and LAHH rails must not be allowed to cool at rates faster than:

    0.5°C per second to 418°C (1.6°F per second to 752°F)

    2.5°C per second 418°C to 218°C (8°F per sec. 752° to 392°F)

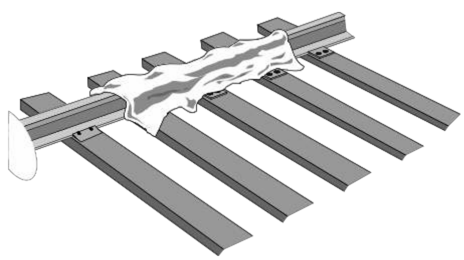


Figure 14.8 - Stock rail a refractory ceramic fiber blanket to cover the post heated area

11. Grind to level and contour using an MP12 (grinding machine). Do not use excessive pressure because it will cause bluing of the rail.

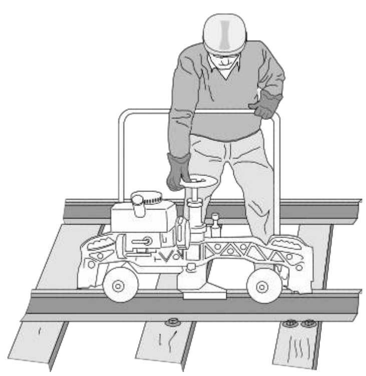


Figure 14.9

12. The repaired stock rail should be checked for alignment several times during repair and not left until cool out. The welder should not leave the work site until there is no further contraction.
13. Remove the 6.4mm (1/4”) shim, oil the repaired area and reinstall the rail braces etc.

    Stencil the field side of the repair area showing:

    A. Month

    B. Year

    C. Welder number

Stock rails may be repaired once only.

Only qualified welders may weld stock rails.

Protection

Success of the welding repairs depends largely on the control of the weld cooling rate. Keep the weld area free from snow and moisture. Welding must not be carried out in heavy rain or falling and drifting snow. A shield must be erected to protect the work area from the wind.

Remember:

Again, it must be stressed, it is essential that the work zone be protected from wind and draughts, which may destroy the gas shield when welding and produce an inferior weld.

Do not undertake welding of high strength stock rails (chrome and LAHH) during rain or snow conditions or when the rail temperature is below 32°F or above 86°F (below 0°C or above 30°C).

Final check

On cool out:

1. Check stock rail alignment for distortion (see Chapter 8: “Distortion and Track Welding”.)
2. An approved graphite, oil or grease must be applied to the heat affected areas of the stock rail and plates in order to provide easy throw of switch and retard the formation of rust.

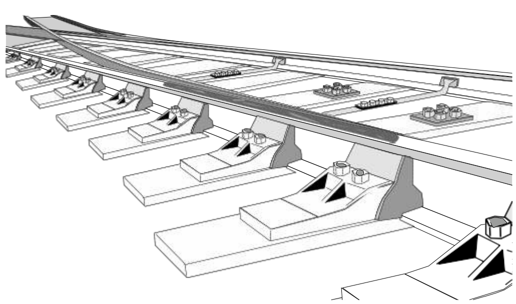


Figure 14.10

Preventive measures

1. When working on live track operating any equipment, it is essential that one employee act as a dedicated lookout, this is known as the "Watchperson/Lookout."
2. The dedicated lookout person must never engage in other tasks, which could interfere with the responsibility of protecting others, but must watch for oncoming hazards in all directions.
3. The proper eye protection is required to prevent arc flashes. The minimum color grade is welder's green 3 but 5 is preferable.

Remember:

The safety watch – is a watch forlife!

Engine burn repair

Introduction

Engine burns are caused by slipping of the locomotive wheels. The friction between the wheels and rail creates a depression in the rail surface. The sudden friction heat generated is subjected to a quick quenching action from the surrounding cold rail metal. This sudden heat and quench creates a hard, brittle metal structure beneath and around the depression, the depth of which depends on the severity of wheel slippage. Left unrepaired the passage of trains worsens the condition. The spot will batter, and cracks will form and grow, resulting in rail failure.

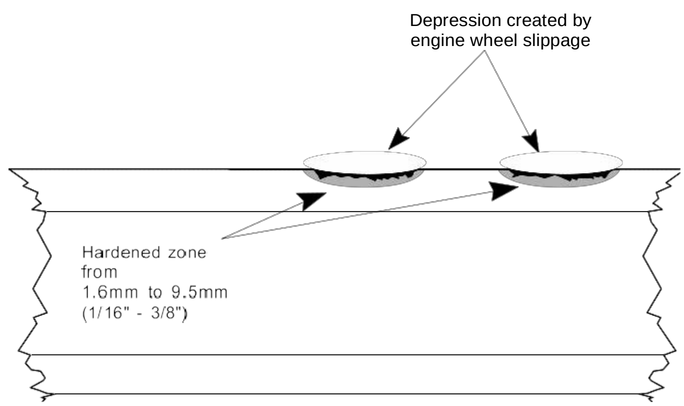


Figure 14.11

Note: Squats and crushed heads are fatigued rail that must be cut out.

Precautions

a) Only qualified welders may repair engine burns.

b) Check rail for tags identifying wear resistant rails or check heat number to identify rail chemistry before attempting repair.

c) - Do not weld during rain or snow conditions.
  - Do not weld if rail temperature is below 32°F (0°C).
  - Do not weld in CWR if the rail temperature exceeds the maximum of the preferred rail laying temperature range of the territory.
  - Do not weld engine burns consecutively unless they are at least 3 meters (10')apart.

d) Any rail having an engine burn exceeding 10mm (3/8") in depth after grinding must not be welded, but removed from track.

e) In concrete tie territory burns up to 3mm (1/8") in depth must be protected by slow order and repaired as soon as possible. Greater than 3mm (1/8") in depth, the rail must be removed from track.

f) Before welding, all cracks and defective metal must be removed by grinding. (Must be checked with dye penetrant prior to welding.)

g) Maximum length of engine burns, including batter, **must not exceed** 250mm (10"). If longer, remove rail from track.

Electric arc method

1. An approved propane heater applying balanced heat at both sides of the base-web fillet and both sides of the rail head must be used.
2. Preheat the weld area to 700°F (389°C) for standard chemistry rail, 800°F (444°C) for chrome rail and 800°F (444°C) for low alloy rail.
3. Post heat to 1100°F (611°C) to normalize standard chemistry rail. Post heat to 1200°F (667°C) to normalize chrome and low alloy rail. Heat retarding blankets must be applied from the endof post heat cycle until 390°F (217°C). Ensure that temperature gradient is asprescribed.*
4. No stage welding. The entire weld must be completed in one application.
5. The electrodes used must be in the same hardness and property range as the railbeing repaired.

   * .9°F (0.5°C) per sec. 1472°F to 752°F (817°C to 418°C) / 4.5°F (2.5°C) per sec. 752°F to 392°F (418°C to 218°C)

Finish grinding

The weld must be ground level after the heat retarding blanket has been removed. When repairing wear resistant rail, the heat retarding blankets must be of the ceramic type. Any flow of metal on the gauge or field side of the rail head at the repaired area must be removed, to conform to the existing rail head shape.

Preventive measures

1. When working on live track operating any equipment, it is essential that one employee act as a dedicated lookout, this is known as the "Watchperson/Lookout."
2. The dedicated lookout person must never engage in other tasks, which could interfere with the responsibility of protecting others, but must watch for oncoming hazards in all directions.
3. The proper eye protection is required to prevent arc flashes. The minimum color grade is welder's green 3 but 5 is preferable.

Remember:

The safety watch – is a watch for life!

Stock rail engine burn repair

1. This circular covers the repair of engine burns in rails by welding.
2. Only arc welding methods may be used for repair of engine burns.
3. Welders employed in the repair of engine burns and stock rail repair must be qualified in the techniques by the Senior Manager of Track & Structures.
4. a) Welding of stock rails must not be undertaken if the rail temperature is below 0°C. In CWR, engine burn welding must not be done if the rail temperature exceeds the maximum of the preferred rail laying temperature range.

   b) Heat retarders must be applied from end of post heat until 390°F (217°C).

   c) Welding of engine burns must not be undertaken during rain or in snow conditions.
5. In concrete tie territory, engine burns up to 3mm (0.125 inch) in depth shall be protected by slow order and repaired by welding as soon as possible. Engine burns 3mm (0.125 inch) or more in depth shall be protected by slow order and removed from track.
6. Sufficient metal must be removed by grinding from the burnt area of the rail to eliminate all cracks and damaged metal. A magnifying glass or dye penetrant must be used in the detection of cracks.
7. Any stock rail having an engine burn exceeding 10mm (3/8 inch) in depth after grinding must not be repaired by welding but must be removed from track promptly.
8. When using the arc method, a dual-purpose heater applying balanced heat at both sides of the base web fillet and both sides of the rail head must be used.

   A thirty six inch straight edge with a dial gauge indicator must be used during pre and post heat cycles to ensure straightness.
9. Stock rail repair must be completed before traffic is permitted.
10. Maximum length of engine burn including batter must not exceed 250 mm (maximum length for stock rails is 30').

Chapter 15: Reclamation of Manganese Steel Track-work

Introduction

Manganese steel is an extremely tough metal with a high resistance to wear from abrasionand impact. Under train wheel impact loads it will work harden from its initial state of about 200 Brinell until it reaches a hardness of 500 Brinell or more. It is because of this characteristic that manganese steel is used in the manufacture of various track castings such as frogs, diamond crossings and slip joints.

General

Through wheel impact, the running surface will tend to flow as it is compressed and work hardens. To prevent chipping, cracking or shearing of the deformed material, it is important that any overflow is removed. This must be done by grinding it well before it becomes excessive. Therefore, frequent inspection must be carried out during the work hardening process.

By timely grinding the casting is maintained to proper contour, which will greatly increase the life of the running surface and substantially reduce the need for repairs by welding. Grinding is the correct way to maintain manganese castings and welding should only be done as a last resort.

A study of the manufacture of manganese steel will indicate that specific precautions and procedures must be taken and used when it does become necessary to reclaim the castings by welding.

Manganese steel, as cast before heat treatment, is worthless for use in track components due to its extreme brittleness. To bring the steel to its useful state it must be heat-treated. This is done by raising the temperature to change the grain structure from its as-cast pearlitic structure, in which the element, carbon, is accumulated in planes throughout the iron grains, to an austenitic structure in which the carbon is mixed with the iron grains.

The temperature used for heat treatment is 1900°F (1056°C) and is maintained for one hour for every 25mm (1”) of thickness of the casting. When the desired heat soaking has been achieved, the casting is then quickly submerged in cold water. The effect is to trap the granular structure of the steel in its austenitic state with the carbon thereby held in solution with the iron grains.

Disregard of heat control, when welding or cutting on the casting, will revert the granular structure to a pearlitic structure with the resulting loss of ductility and work hardening properties.

The effects of heat on manganese steel

The low thermal conductivity of manganese steel, 14% that of mild steel at room-temperature, is a great aid in the welding operation. However, although dissipation of welding heat to the casting is slow, heat build-up, unless controlled, will eventually raise the temperature of the parent metal to a point where the grain structure will begin to change from austenite back to pearlite. It will become brittle and the weld metal may separate from the parent metal.

Caution:

Do not allow water to contaminate the weld area or the welding electrodes.

Persons performing the welding operation must ensure that gloves, clothing and electrode holder remain dry.

Preparation of the casting for welding

Certain areas on the surface of manganese steel track work castings are subjected to impact and heavy concentration of loads. It is in these areas that defects first occur and it is here that all of the work hardened metal on the worn surface must be removed to a depth of 6mm (1/4”) prior to welding. The removal of the metal by grinding should be done to provide a horizontal shelf to receive the weld metal. The use of arc-air or arc slice torches is permitted for the removal of large defects but great care must be exercised not to overheat the casting and these operations must be followed by grinding.

To ensure that all work hardened metal has been removed, a rough test may be made with an ordinary center punch of about 200mm (8”) in length with the point end ground round. The punch will have little effect upon steel having a hardness of more than 400 Brinell, but will show an appreciable impression on steel of about 250 Brinell or less. Uniform blows on the punch alternately on the surface being prepared, and on the manganese which has not been run on, will indicate when the area to receive the weld deposit is approximately the same hardness as the unused part of the casting. The impression of the punch should appear about the same size when all work hardened metal is removed. Sharp edges along the flange-ways should be rounded slightly before welding is started.

During welding and until cool out, the frog should be raised slightly at the center. This will prevent any heat distortion.

To ensure that all components are tight, all guardrail, frog and body bolts must be checked and tightened if necessary. Broken or missing washers must be replaced.

Preheating

When welding manganese steel in cold weather below 60°F (15.6°C), the casting should be preheated to 100°F (37.8°C) to prevent thermal shock to the casting thereby preventing the cracking of both the weld and parent metal.

NEVER post heat manganese steel.

Wear limits and buildupdimensions

The wear of a manganese frog should always be checked with a straight edge, as the amount of visible wear of the wheel riser may prompt unnecessary welding. Transfer section wear is determined by placing a straight edge across the frog and measuring the distance between the straight edge and the point, less the height of the wheel riser.

Minimum allowable transfer section wear before welding: If the wear does not exceed 10mm (3/8”), the frog should not be welded.

Maximum allowable wear: Not closer than 38mm (1 1/2”) to the bottom of the flange-way.

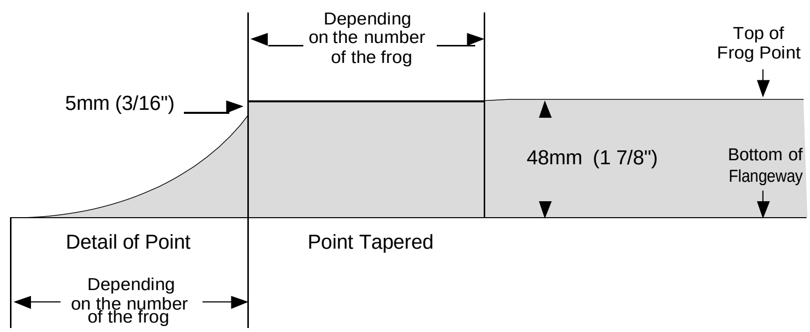


Figure 15.1 - Detail of point

For example: a number 12 frog will be sloped to 3/16 less than full flange-way depth for 6 inches from the ½ inch point.

- A number 16 frog … >>>.. for 8 inches from the ½ inch point.
- A number 20 frog … >>>.. for 10 inches from the ½ inch point.

Rigid rail and spring frogs have no wheel risers.

Determining wear of the raised wheel guard on self-guarded frogs

To check the wear, place the flange-way gauge at the actual 16mm (5/8”) point, with the side stamped “S.G.” toward the guard. If the clearance between the guard and the gauge exceeds 6mm (1/4”), the frog should be isolated and either restored or replaced.

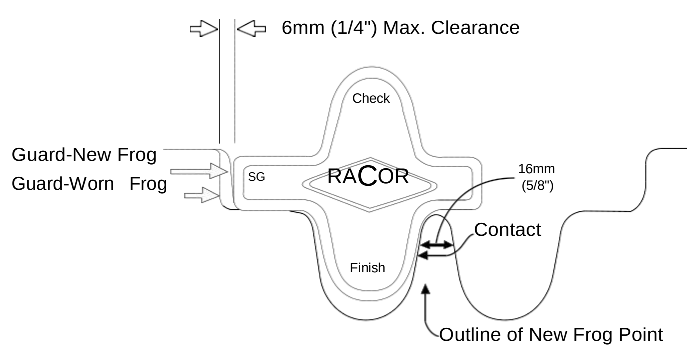


Figure 15.2

Arc welding procedure

To keep the heat as low as possible when welding manganese steel, the electric arc method must be used. Electrode size must not be larger than 4.8mm (3/16”) and preferably 4mm (5/32”) for use on sections, which may be more subject to overheating, such as the frog point.

The welding amperage must be kept as low as good fusion requirements will permit for the size of the electrode used and a short arc should be maintained.

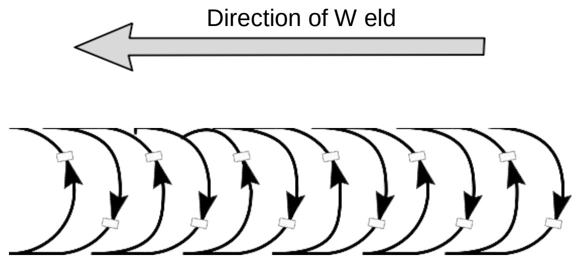


Figure 15.3 - Bead pattern

The weld beads should be deposited in a half moon weave with the points of the half-moon in the direction in which the weld is progressing. Width of the deposit should not be more than 1-1/2 times the diameter of the electrode or maximum width of 5/8 of an inch.

The deposit should be made heavy by working the arc back into the deposit while maintaining the half-moon weave to take the heat away from the parent metal and to discourage cracking. Bead craters must be filled to the height of the body of the bead before the arc is broken.

Beads must be thoroughly peened (3 or 4 per inch of weld) using moderate blows immediately on completion of each individual bead in order to relieve shrinkage stresses, and to provide denser material, which would be less subject to flow and deformation. The thermal expansion rate of manganese steel is one and half times that of ordinary steel and the beneficial effect of stretching the metal by peening cannot be overstressed. Thermal conductivity is about 14% that of mild steel at room temperature, and this contributes to heat buildup during welding.

The length of each individual bead should be the amount of deposit using one-half of an electrode and should produce approximately a 6-8 inch bead. The parent metal or underlying weld metal should be thoroughly cleaned by chipping and by wire brushing before depositing each bead.
Lack of cleanliness should not cause welders to use greater amperage than is required. Bead distribution should be planned so that there will be no excessive stress concentrations or localized overheating of the casting.

Probably the most susceptible to overheating and heat build-up is the point of frogs and crossings. Consequently, it is advisable that this section should receive the first bead. The following weld increments, about 6-8” in length, should then be intermittently deposited along the flange-way edges.

Follow the same procedure along each manganese wing. Then, using a 350°F (200°C) temperature indicating crayon, mark each flange-way wall 6mm (1/4”) below the weld line on the frog point and each wing rail. At any time when the temperature indicating crayon melts, taking on a greasy appearance, welding should be withheld in the area until the temperature drops to a workable level. The inter-pass temperature must be below 375°F (208°C).

In order to control the heat of the casting, planned distribution of the weld increments is important, as well as necessary to reduce lost time waiting for the casting to cool and to avoid stress concentrations. Distribution should be planned so that starting and finishing points of individual parallel beads are staggered.

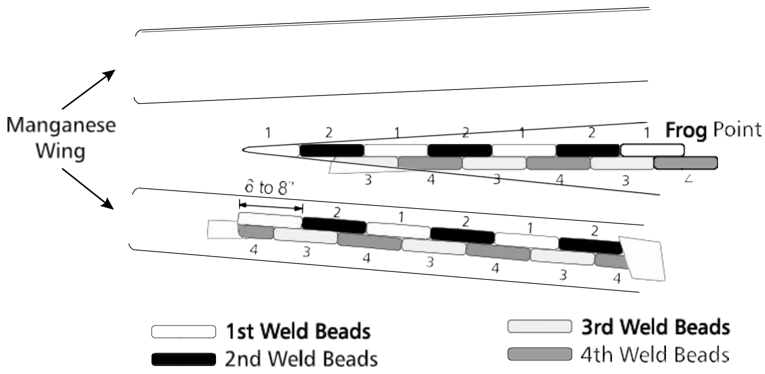


Figure 15.4

Continue the bead distribution until the height of the completed deposit is slightly higher than the required finished dimensions to permit the removal by grinding of all irregularities. On wide surfaces such as on diamond crossings, beads can be planned so that the deposit will be made at right angles to the underlying beads.

Any batter or mismatch at heel or toe must be built up to provide a smooth wheel transfer.

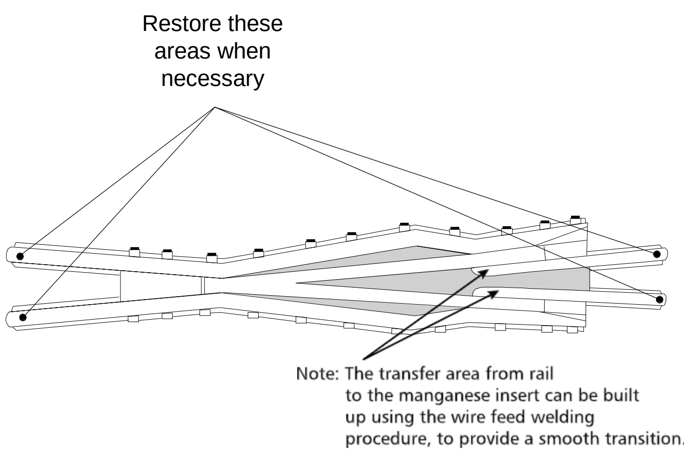


Figure 15.5

Grinding the weld

On finish grinding of the completed weld, the surface must be smooth and provide the necessary easements. The walls of the flange-ways must be of proper slope and smooth with no overhang of metal, or undercutting of adjoining beads. The flange-ways must be straight and clear to 47.625mm (1-7/8") opening at gauge line. The gauge side edges of the flange-ways are to be rounded to a 14.287mm (9/16") radius to permit anticipated flow to take place before a sharp edge is created.

If the frog is of the rail bound type, the contact edges between the manganese casting and the rail steel must be slotted to about 4.5mm (3/16") depth to lessen metal flow during the initial work hardening period.

Grinding 136 lbs. RE heavy point integral base rail bound manganese (rbm) frogs

Care must be taken when grinding Heavy Point RBM Frogs. They must be ground as per standard plan. If the points are ground according the older standard contour, the result will be a greatly shortened life of heavy point frogs.

A Flange-way Gauge has been developed for use to determine wear of Self Guarded Manganese (SGM) Frogs and to accommodate the slope on the new 136 RE-RBM Frog points. Thesegauges should be used as advised by the welders Supervisor and GO Transit's Corridor Maintenance SeniorManager of Track and Structures.

Never use the MC-2, MC-3 grinder to remove the over flow on the point and manganese wings of RBM frogs. It may result in over grinding the sidewalls.

Maintenance of manganesediamonds

Diamond inserts should be reversed periodically. The reasons for such rotations is to equalize the wear of all parts and reverse the metal flow so that it will flow back into itself and work harden. This should be repeated until the maximum hardness in the impact area isreached.

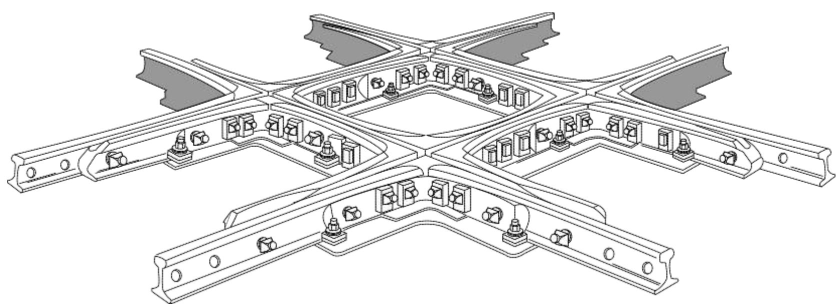


Figure 15.6 - Reversible insert diamond

Frequent inspection of diamonds must be carried out during the work hardening process, and any spreading or overhang of metal must be removed by grinding and the edges restored to proper contour.

To minimize wheel impact, the standard flange-way clearance of 48mm (1-7/8") must not be exceeded.

The welding of manganese diamond castings should be considered only as a last resort. It is strongly recommended that they be maintained by grinding as long as possible. Should welding be necessary, it is usually only to replace small pieces which are spalling.

A diamond is usually not restored until the running surface wear is about 6mm (1/4"). This measurement is taken 37mm (1 1/2") in from the edges of the flange-ways. Periodically, the diamond corners must be aligned. In order to maintain this alignment, the maximum included clearance between the baseplate stop blocks and the diamond must not exceed 3mm (1/8"). If it is necessary to adjust, the stop blocks may be cut off and re-welded into position.

When the escalating cost of purchasing new manganese track components is considered, it can readily be seen how important it is to timely and properly maintain our existing stock.

Maintenance of manganese diamonds using wire feed

Use REVERSE polarity and follow the manufacturer's specifications to set up the machine

Your beads should be about 5/8th inch wide, - about the width of a dime, and no longer than 14 inches. Wire stick-out should be maintained at 1 inch to ensure proper bead penetration and arc force.

Once your bead is down, use the needle scaler to remove the flux. You should scale in thesame direction that you laid down the bead.

Now, peen the bead. Peening is designed to help relieve stress that has been introduced to the component through the welding process.

Proper peening involves placing 3 to 4 dimples per inch - working in the opposite direction that you laid your beads.

The benefits obtained by peening are: increased resistance to fatigue failure, corrosionfatigue, stress cracking, hydrogen assisted cracking, fretting, galling and erosion caused by cavitation.

Next, clean up the bead with a wire brush and then cool the component with compressed air.

Temperature management is a critical part of good track component repair. One of the advantages of the wire feeder is that it generates less heat within the component than other, more common welding techniques.

During the welding process monitor the temperature of the component with a tempilstik or an approved temperature measuring device to ensure inter-pass temperature is maintained below 375°F (208°C).

It is good practice to measure the temperature ½ inch away from the last welded bead.

Never allow the component to exceed 500°F(277°C).

Another useful technique in managing temperature within the component is skip welding. However, proper peening techniques must be applied before the bead cools.

If there are several defects in the component, for example both the point and the wings need repair, then, alternate your beads between them.

This "skip welding" will allow the area to cool between successive beads.

Your work area will determine the bead length, but remember, they should never exceed 14 inches.

The problem with long beads is that because you should weld in one direction and then peen in the opposite, by the time you peen the start of the bead, it will have cooled to the point where peening does no good.

Once the build-up is complete and the component should be ground to profile.

Welding Procedure for Rail BreakCastings

1. Initial Inspection

a) Thoroughly clean total assembly, prior to specific area cleaning, using cleaning agents approved by Metrolinx. One recommended cleaning/degreasing agent is Tricholoroethane ($C_2H_3Cl_3$).

b) Surfaces must be free from rust, scale, grease, oil, wax, dirt, water and other deleterious substances not conducive to good welding procedures.

c) Grinding surfaces to remove all cracks and sharp corners.

d) Prior to welding check all surfaces for cracks.

e) The following NDT alternatives shall be used to detect cracks, if determined necessaryby GOTransit'sCorridor Maintenance SeniorManager ofTrack& Structures.

   i. Magnetic particle
   ii. Die penetrant
   iii. Ultrasonic

f) All initial inspection results shall be documented and discussed with the Senior Manager of Track & Structures prior to commencing weld repair.

2. Welding

1. Welding shall be undertaken only by a welder operator or Contractor approved by the Canadian Welding Bureau to the requirements of CSA Standard W47.1 Certification of Companies for Fusion Welding of Steel Structures.
2. Preheat and inter-pass temperature shall be maintained at 315° C (600° F) minimum.
3. All electrodes covered in this specification shall be purchased in hermetically sealedcontainers and stored in a holding oven maintained at 150° C (300° F), or shall be dried for at leasttwo (2) hours at 450-500° F,prior to use. Electrodes that are not used within two (2) hours shall be re-dried. Any wet electrodes shall be discarded.
4. Welding procedure to be strictly adhered to with one exception being a Contractor whowishes to submit a total welding and heat treatment procedure to GO Transit's Corridor Maintenance Senior Manager Track & Structures for review and approval before commencement of thejob.

   i. Filler Metal and Welding Parameters

   TUFTRAK 1, Identification: red Tip, AC-DC Reverse Polarity. Size: 5/32 (amperage 110-14), 3/16 (amperage 135-175), ¼ (amperage 165-190)

   ii. Position

   The welding shall be carried out in the horizontal position or vertical up position where practical.

   iii. Welding Sequence

   The welding shall be made using stringer beads holding a short to medium arc. A slight weave (= or – ¼ in.) may be used. Long deposits may be made without danger of cracking.

   Overheating of base metal at temperatures approaching the critical range no higher than 710° C (1200° F), must be avoided; low welding current combined with slow travel contributes to the heat problem.

iv. Appearance of Weld Deposit

The welding current and manner of weld deposition shall be such that there shall be no undercutting on the side wall of the groove or the adjoining base material.

All welds shall be wire brushed and all welding flux removed before laying the next bead. Any cracks or blowholes that appear on the surface of any bead shall be removed by chipping or grinding before depositing the next bead.

v. Peening

Peening is not permitted

vi. Inspection

Each weld layer shall be NDT inspected by the Magnetic Particle method.

Powered rotary file shall be used to shape contours after welding and finished welds shall be inspected again (Magnetic Particles, Ultrasonic). Final inspection report shall be issued at job site to GO Transit's Corridor Maintenance Senior Manager Track & Structures.

vii. Apply post-weld heat treatment. While still hot from welding, the work piece shall be brought to the range of 595-650° C (1100-1200° F), maintained at this temperaturefor sufficient time (1 hour per inch of base metal thickness; greater dimension) and allowed to air cool to the ambient temperature. No outside stimulus may be applied to speed the cooling process, although an insulation layer of dry sand or insulation maybe used to provide a slow cooling process.

3. Final Inspection

1. Repair welds will be NDT and visually inspected after post weld heat treatment. The results will be recorded and submitted to the GO Transit's Corridor Maintenance Senior Manager Track & Structures.
2. If any weld is defective, the total weldment shall be gouged out and redone followed by visual and NDT methods as specified in this procedure.
3. Absolutely no spot repairs will be permitted.

Reclamation Procedure for <u>Alloy</u> Steel Rail Wedge and Rail Break Castings

1. Remove visible defects by chipping or grinding to clean, solid metal. If the amount of metal to be removed is so great as to render chipping or grinding impractical, a burning torch maybe used, however, the casting must be preheated to 400-600° F for burning. Any scale caused by the burning must be chipped or ground off.
2. Carry out magna-flux inspection to ensure that all cracks have been removed.
3. When all cracks have been removed, heat the entire casting in a furnace to 400-600°F.
4. Remove the casting from the furnace and weld while above 400° F. If the casting requires extensive welding, means of keeping it above 400° F while welding should be provided, such as small gas burners under the casting. Temprilstiks should be used to check the temperature.

The welding electrode may be selected from one of the following:

AWS-AST Classification E –12018

Lincoln BU 90

Canadian Air Liquid CX 90

Electrodes should be from previously unopened containers. If exposed to the atmosphere, electrodes will absorb moisture in their coatings and will not give satisfactory results unless they are baked for 1 hour at 300° F and use while warm. When an electrode container is opened the electrodes should be removed and kept in an oven or cabinet at 250-300° F until used.

If for any reason, welding in interrupted, the entire casting should be covered with insulation and kept above 400° F by externally applied heat such as small gas burners as mentioned above.

5. When all welding has been completed, the casting should be handled in one of two ways:

   A. Cover with insulation and allow to cool to room temperature or

   B. Place immediately in furnace at 400-1200° F.

6. Normalize

   If the casting was handled as in 5A, place in a furnace no hotter than 1200° F, and raise the temperature to 1525-1575° F. If handled as in 5B, increase to 1525-1575° F.

   Hold the casting in the furnace at 1525-1575° F for 3 hours. Avoid excessive oxidation, decarburization or scaling while heating.

7. Remove the casting form the furnace and cool in still air to below 600° F.

8. Temper

   Replace the casting in a furnace and heat to 1050-1075° F. Hold for 3 hours and air cool.

9. Carry out machining or grinding operations to give the required finished dimensions and surface conditions.

10. Each casting should be identified so that at a later date it can be determined by whom it was welded and which welding electrode was used.

Chapter 16: Field Welding

1. In-Track Electric Flash Butt Welding

Introduction

Conditions

This chapter and section describes the procedures, specifications and limitations for the in-track fabrication of continuous welded rail (CWR) using Electric Flash Butt (EFB) welding equipment. Two types of Electric Flash Butt (EFB) welding machines are covered: 1) standard machines and 2) machines equipped with hydraulic jacking equipment capable of pulling rail ends together.
The type of weld produced by EFB welding is identical 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.
Furthermore this chapter section describes the restrictions, procedures, and testing of in-track Electric Flash Butt (EFB) welding for both Holland and Plasser EFB welding equipment.

References

GO Transit Track Standard document section 7.0 – Field Welding

Overview

Electric Flash Butt (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.

Basically, 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 around the joint. This material is then sheared and ground off. The joint is then electro-magnetically tested for soundness.

Precaution must be taken to prevent electrical shorting of the track circuits. Track shunts may need to be placed or completely disconnect the track circuits, prior to EFB welding. Check with manufactures recommendations, along with GO Transit's Corridor Maintenance Senior Manager of the S&C department.

Procedures

This document describes the restrictions, limitations, requirements, preparation, welding procedures, and testing of in-track Electric Flash Butt (EFB) welding using both Holland and Plasser equipment as well as applicable procedures in the GTTS document.
The in-track Electric Flash Butt (EFB) welding process can be broken down into three basic stages: 1) preparation 2) performing, and 3) completion.

1. Preparation:
    - Obtain authority to occupy the track.
    - Identify and mark rail to be removed, if necessary.
    - Remove rail fasteners and anchors as required.
    - Cut and remove old rail, if necessary.
    - Remove ballast at weld locations to facilitate shearing and installation of rail alignment jacks and welding heads.
    - Inspect and lay replacement rail, if necessary, securing as required.
    - Prepare and align rail ends.
2. Performing the weld:
    - Install welding head (and rail puller, if required).
    - Perform weld following procedures for specific equipment and type of weld (head or closure).
    - Remove welding head (and rail puller, if required).
3. Completion
    - Shear and grind weld.
    - Inspect and test weld.
    - Mark rail, identifying weld.
    - Return track to service.

The specific procedures vary slightly depending on the type of EFB welding equipment used (Plasser or Holland) and the type of EFB weld being performed (head or closure).

Contents

Procedures

I Definitions

Head Weld (Free End or Plug)

An electric flash butt weld that uses the welding head only, and where at least one rail is unfastened, or free to move. 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.

Puller-Assisted (Closure) Weld

An electric flash butt welding process that uses both a welding head and a hydraulic jacking system, both rails to be welded are fastened at the far end and the jacking equipment pulls the other rail ends together during the welding process. If replacing a section of CWR, this would be the second or closure weld and would introduce internal stress to the CWR.

II Restrictions

General Restrictions

All fire-fighting equipment must be readily available, in working order, and ready for use for all aspects of the EFB welding and grinding operation, including a field level risk assessment of the work area and completion of a HOT WORK permit to the satisfaction of GO Transit.

- EFB welds are to be performed on blank (undrilled) rail ends unless both of the following conditions are met:
  1. the end hole is not drilled; and
  2. when completed the weld is not closer than 4” (101 mm) to the edge of any hole in the rail.
- EFB welds are prohibited within 2” (50 mm) of any cad-weld or copper bond wire installation. All copper must be removed by cropping the rail end or by grinding.
- EFB welds are prohibited on all rail ends that have been repaired or built up by welding.
- EFB in-track welds shall not be made closer than 3’ from an existing EFB weld or Thermite weld to ensure that the puller clamps ***are not clamped*** on an existing Thermite or EFB weld.
- EFB welding must not performed when there is excessive ***lateral pressure*** on the rail ends to be welded.

  Under normal conditions EFB welds can be performed on rail in tangent track or in curves with a maximum degree of offset of: under 2°

  If EFB welds must be performed on rail that exceeds the offset limits above, the rail must be removed from tie plates or concrete shoulders so that the rail ends to be welded are straight to a 36” straight edge.

Temperature Restrictions

- EFB welds performed at rail temperatures less than 40°F (-6.5°C) must be covered immediately after shearing until cooled below 900°F (483°C).

Weather Restrictions

- EFB welding is not permitted in heavy moisture conditions such as heavy rain, sleet or blowing snow.
- EFB welding is permitted in moderate moisture conditions if the following conditions are met:

  a. The rail can be kept dry and no clamp slippage occurs; and

  b. The electronic control systems of the welding equipment can be kept dry and operate properly.

  c. It is the responsibility of the Contractors' Welding Supervisor and the In-Track Welding Unit operator on site to determine that weather conditions are safe for personnel to properly perform their duties and ensure proper operation of the EFB welding unit.

Rail Temperature	**Weather Conditions**		
	Clear		**Wind, Rain, or Snow**
Above 40 °F / 5 °C	* No Cooling Restrictions		* Apply weld cooling cover immediately after shearing
	* A weld cooling cover is not required		* Leave cover/ blanket in place until the weld has cooled below 900 °F (483 °C)
Between 40 °F and -10°F / -5°C and -23 °C	* Apply weld cooling cover immediately after shearing		
	* Leave cover/ blanket in place until the weld has cooled below 900 °F (483 °C)		
Below 32 °F / 0°C	*** Low Consumptions EFB welds are not permitted**		
Below -10 °F / -23°C	*** EFB welds are not permitted**		

Traffic Restrictions

- Train traffic or heavy pieces of work equipment (including in-track welders) are not permitted across a completed EFB weld until:
  - the running surface and gauge face are rough ground within thirty thousandths (0.030) (2 mm) of an inch;
  - the weld has cooled below 700°F (371°C);
  - all wedges, blocks, and jacks have been removed; and
  - the weld has been supported by a tamped tie on each side.
  - plug/glue and spike or clip ties.

Concrete Tie Pads

- Prior to performing an EFB weld, concrete tie pads and insulators must be removed from one tie on each side of the weld gap. To protect pads from damage.
- After completion of the EFB weld, concrete tie pads and insulators must not be

replaced until the temperature of the rail base 1" from the edge of the tie pad has cooled below 250° F (121°C).

III Rail Requirements

- All replacement rail must be examined by qualified personnel prior to welding and mustmeet the requirements of GO Transit's Track standard document section 3.0Rail.
- Allowable rail lengths to be EFB welded are:
  - Tangent tracks, rail plug: Min. 12'
  - Curved tracks,rail plug: Min19'6''

  Glued bonded insulated joint assemblies are considered to be one unit length.

  (Care must be taken to ensure enough room to clamp weld head onto rail end.)
- Maximum rail length for EFB welds to be completed with welding head only; with the rail seated in the tie plates and all anchors removed and spikes nipped; or with rail on concrete ties with clips and insulators removed:
  - Maximum unrestrained rail will be determined by CWR procedures.
- Maximum rail length for EFB welds to be completed with welding head only. Rail on rollers every 30 feet:

  900' is the maximum length of pull for EFB welds with the 70 ton weld head, with rails on rollers spaced every 30 feet apart.
- Replacement rail must compensate for rail consumed in the EFB welding process. For closure welds in joint elimination operations the replacement rail for the closure weld must be longer than existing rail as follows:

WELDING UNIT	Normal Rail Consumption	Overlap for Closure Weld	Replacement Rail Additional Length
Plasser K355 with Superjack, Chemetron	2.00"	1. 75"	1. 75"
Holland	1.50"	1. 25"	1. 25"
Holland Low consumption	0.75''	0.50"	0.50"

- 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 guidelines:

  Following all UTT requirements found in the GO Transit Track Standard document.
  - 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" 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.
  - Replacement (and existing) rail must be inspected for defects such as severe head checking or spalling, crushed heads, wheel burns, battered welds, welds that are kinkedto gauge or field, welds that are low or crowned outside of allowable tolerances, and a surface bend condition in the rail joint. The length of replacement rail shall be sufficient to remove these defects. If any of these conditions exist in the replacement rail, the replacement rail must be rejected.
  - Existing Thermite welds must be eliminated.

- Rail must be cut so that ties will not have to be moved to perform the weld — that is, the weld must be performed in an existing tie crib. Minimum distance from the edge of tie is 4” (GO Transit Track Standard document sections 7.1.2,General Information, 7.2Thermite Welding) to allow clearance for weld shear dies.

- Replacement rail should as closely as possible match the weight/section, contour, and height and gauge face wear as the existing rail.

  Note: Replacement rail of a different weight/section or wear pattern is permitted only if maximum difference in height or width between replacement rail and existing rail does not exceed 3/16” (5 mm).

  If the height difference is greater than 1/8” (3 mm) but less than 3/16” (5 mm), EFB welds may be performed if a maximum 1/8” (3 mm) inch difference is confined to the base and the remainder (up to 1/16”) (2 mm) is the vertical offset on the head. (Exception new 141 / 136) However, welds must meet finished weld alignment tolerances.

- Replacement rail must be the same rail type as the existing rail — that is, replace standard carbon rail with standard carbon rail and premium rail with premium rail. (Metallurgy must be equal to or better than the existing rail).

IV *Preparation*

In this part of the chapter we look at the main stages of preparing for an EFB weld, from identifying rail to be removed, if required; marking the location of the weld(s); removing tie plate/pad, rail fasteners, removing ballast at the weld locations; preparing the rail ends; and pre-aligning the rails prior to installing the welding machinery.

Preparing the Track

- Obtain authority to occupy the track.
- Inspect and mark old rail to be removed.

  The maximum length of rail removed should not exceed the maximum length of rail that can be replaced as per Rail Requirements above.

  Cut marks should be located in cribs so that ties will not have to be moved.
- Cut rail at marks and all rail ends to be welded must be cut with an approved rail saw. Torch cut ends are not allowed to be welded.
- Remove rail fasteners and anchors as required to remove old rail.
- Inspect and lay replacement rail, if necessary, securing the rail as required, and complete the weld.
- Remove tie plates/pads at weld location(s) from ties on either side of the weld crib.
  - To provide a flat base for the EFB welding head, wood ties that are plate cut more than ½” deep should be adze-leveled approximately 12” on each side of the plate.
- Remove spikes/clips from ties on *each* side of the weld crib.
  - Head welds: Min. 3 ties each side.
  - Closure welds with Puller: Min. 5 ties each side.

Removing (or not installing) Rail Anchors/Clips

- For head welds:
  - Do not install rail anchors or clips on the replacement rail, allowing free movement ofthe rail during welding.
  - Do not remove rail anchors/clips from the existing rail.
- For closure welds:
  - Remove all rail anchors/clips for a minimum of 150 feet on each side of the weld.
  - 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.
  - Where there are fixed structures, DO NOT remove rail anchors/clips closer than 200 feet from the structure.

Note: On concrete ties in curves, install distressing clips on every 15th tie to ensure safe travel of the EFB welding equipment vehicle.

Removing Ballast

To prepare ballast for the installation of shears, alignment jacks, weld heads/pullers, and spreader bars:

- Remove 6" of ballast from under rail at weld location to provide clearance for shear.
- Dig holes on each side of the weld crib for rail alignment jacks:
  - For pancake jacks: 7" deep in the *first crib* on each side of the weld crib.
  - For hydraulic track jacks: 3" deep in the *third crib* on each side of the weld crib.
- Remove and level ballast to the top of the ties in the center of the track and on the tie shoulder for three (3) or four (4) ties on each side of the head weldingcrib.
  - For head welds (the EFB welding head only): three (3) ties.
  - For closure welds (EFB welding head and Jack/ Puller assembly): five (5) ties on each side of the weld crib.
- If a spreader bar is used for closure welds, remove 4" of ballast in third tie crib from weld crib.

Preparing Rail Ends

To prepare both existing and replacement rail ends for EFB welding:

- Inspect rail end cuts for square-ness. Cuts must not be more than 1/8" out of square.
- Remove all dirt, grease, mill scale, and rust on both rail end faces down to bright metal.
- Where the welding electrodes and rail pulling pads contact the rail:
  - Clean all dirt, grease, mill scale, rust, and raised lettering down to bright metal, flush with the rail web surface.
  - Distance will be determined by type of equipment used.
- Remove by grinding all rail steel overflow (lip):

- From the side of the rail head if lip is greater than 1/8".
- Underneath the head of the rail on both the gauge and field side for a distance of 6" from the rail end.

- When a weld is cut for a re-weld, cut using approved rail saw or oxy-fuel gas torch. Use of an approved abrasive rail saw is preferred.
- In the case of emergency, torch cutting of the rail is allowable provided that the procedures in GO Transit Track Standard document section 8.1.9 are followed.

General Housekeeping

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 a safe distance from the welding area.

V Rail Alignment

As mentioned above (see Rail Requirements) new rail should as closely as possible match the old rail in section/weight and vertical and horizontal wear so that differences in rail height and rail head width do not exceed 1/8".

Prior to welding, old and new rail is 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.

The rail is also horizontally aligned so that any difference in rail head width (within the allowable tolerance) is divided equally between both sides of the head.

The rail webs must also be aligned vertically. Any difference in the width of the web to a maximum of 0.040 inch is finished by grinding.

Rail Alignment Procedure – Pre-crown (Vertical)

- Excavate ballast under (new) rail as described above for the type of jack being used.
- Install jack(s) under (new) rail.
- Release (new) rail from ties as needed.
- Butt the rail ends.
- Adjust jack to visually align crown of rail.
- Lay a 36” straight-edge along the crown of the rail across the rail joint with the gap in the straight-edge bridging the joint.
- Insert a taper gauge between the rail crown and the straight-edge
- At no point along the length of the straight-edge should the gap between the straight-edge and the rail crown exceed 0.030 in. on each rail. Pre-crown may very with rail size length, and ambient temperature. Pre-crown can range from 0.060-0.120. Adjust if necessary to meet post weld finish check.

Rail Alignment Procedure –Horizontal

- Lay a 36” straight-edge along the gauge side of the rail head across the joint with the gap in the straight-edge bridging the joint.
- Insert a taper gauge between the rail head and the straight-edge and note the maximum reading.
- Repeat for the field side of the rail head.
- Adjust the horizontal alignment by tapping the replacement rail laterally until any difference in width (up to the allowable maximum) is evenly divided between both sides.
- Clamp the welding head into place following the manufacturer’s procedures.
- Recheck the vertical and horizontal alignment to ensure the rails have not gone out of alignment.
- You are now ready to proceed with the weld.

VI Performing the Weld

General Procedure

Refer to the manufacturer’s operating manuals for specific instructions on the safe operation of the Electric Flash Butt (EFB) welding equipment.
Generally, the procedure is as follows:

- Attach the welding head and (if necessary) rail puller
- Perform Weld (see Guidelines below)
- Remove welding head and puller
- Shear off extruded metal
- Finish grind the weld

The actual procedures may vary slightly depending on the equipment used and the type of weld being done.

General Guidelines

Basically, the EFB welding process can be divided into the following phases:

WELDING CYCLE CURRENT PHASES:					
MANUAL RAILEND SQUARING	UNSTABLE FLASH	CONTINUOUS FLASH	PROGRESSIVE FLASH	UPSET CURRENT	HOLDING TIME *
VARIESBY RAIL SQUARE-NESS	20 – 40 SECONDS	VARIED BY RAIL SECTION & TYPE	8 – 10 SECONDS	1 SECOND MINIMUM	9 SECOND MINIMUM
When using the Super Jack/puller for a closure weld, the jack will hold the rail from moving until the weld has cooled below 700°F (371°C).					
*Procedures may vary depending on type of weld (low consumption) and manufacture.					

The four middle phases involving the application of current is the actual welding process. During these phases, any interruption of the flash current or of welder head platen movement, or during closure welding failure of the hydraulic jacks to pull or hold the rail, will result in a defective weld.

A defective weld must be removed and the rail re-welded. Note that removal of rail to remove a defective weld may result in the need to insert a rail plug in order to maintain the correct PRLT (Preferred Rail Laying Temperature).

Defective Welds

A weld must be considered defective if any of the following occurs:

- Clamp or puller slippage during any stage of the welding process, including holding time.
- Interruption of platen travel or current during the last 1/2” of travel in the final flashing period prior to upset.
- Upset Current of less than one (1) second duration.
- Upset Blow of less than 1/2” or greater than 3/4”.
- Upset pressure must conform to the type of weld and manufactures equipment.
- Holding time of less than 9 seconds.

Rejected welds must be cut through the weld centerline and re-welded. If the weld is rejected again, the rail must be cut 4” on both sides of the weld centerline before re-welding.

Welding Machine Electrodes

Proper size electrodes must be used for the rail section being welded. See the manufacturer’s operating manual for proper electrode size.

Welding head electrodes must be inspected after each weld. To ensure that the electrode makes complete contact with the rail, the electrode surface must be kept clean and smooth.

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 rail steel material, bluing or arching.

Hydraulic Rail Pullers

When a hydraulic rail puller (Super Puller/Jack) is used in conjunction with the EFB welding head, the pressure must be maintained on the completed EFB weld until the weld has cooled below 700°F (371°C).

Welding Machine Clamping and Upset Removal

The clamp area in the web of the rail shall be inspected on every weld for gouges or slippage.

Any gouge or slip marks into parent metal shall be cause for the weld to be rejected.

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.

Post Weld Crown Check

Immediately following the removal of the welding head check the crown as follows:

- Place a 36” cut-out straight-edge on the top surface of the rail with the gap (cutout) over the weld.
- Insert a taper gauge between the straight-edge and the rail surface.
- The gap between the straight-edge and the rail crown should be between 0.080 in. 0.120 in. combined.

Chart Recorder

A three-channel chart recorder must be operational and accurate to monitor the following welding parameters:

- Welding time
- Welding current
- Welding force, including upset force
- Platen travel (rail consumption, displacement)

The recorder must be calibrated at beginning of each shift and the tape must be marked to indicate calibration.

Calibration is conducted by the Contractor’s Representative, with a Metrolinx-GO Transit Representative present to verify.

The following information is copied to the EFB welding chart from the recorder:

- Daily: Date and Location
- Each Weld: The consecutive weld number, corresponding to the weld number painted on the rail. 3' from weld with 2" letters on the gauge side of the rail. As per GTTS 8.1.11

VII Shearing

Immediately after removing the welding head the excess metal extruded around the joint during the welding process shall be sheared off.

Shear dies must be maintained not cut into or tear parent rail steel.

Warning: The extruded metal and rail ends will be very hot. Use extreme caution when shearing.

VIII Finish Grinding

When the rail has cooled to 400°F (204°C) or less, any remaining metal extruded around the weld is ground off from the running surface, the gauge and field sides of the head, and the web collar and base.

All sharp edges and burrs must be removed.

Use caution when grinding. If “bluing” of the rail or weld occurs, the weld is defective and must be removed.

Once the rail has cooled to ambient temperature, the alignment of the rail ends is checked and the rails ground to taper or gradually introduce any acceptable offset.

Note: Maximum offset must not exceed 2mm (0.080")

Running Surface of the Rail Head

Finish grinding of the running surface of the rail is done with a cup-type grinding wheel.
Finish grinding of the surface of the rail is performed as follows:

- Grind the running surface of the weld, leaving the weld maximum 0.015 of an inch high and lightly tie in the weld/rail interface.
- Grind the running surface of the weld flush with the parent rail head surface.
- Grind the running surface of the weld to exactly match the contour of the rails. A radius is to be applied to the gauge and field edges such that no sharp edges remain.

When the rail has cooled to ambient temperature check the alignment of the head surface as follows:

- Place a 36” straight-edge on the top surface of the rail with the weld at the midpoint (do not use a straight-edge with a centre gap).
- Insert a taper gauge between the straight-edge and the rail surface.
- At no point along the length of the straight-edge should the gap exceed 0.015 in.
- If a vertical offset exists between rails:
  - Grind the weld flush with the low rail.
  - Grind the high rail so that the offset is gradually introduced as per Table X up to a maximum of three (3) feet from the weld.

  Note: Maximum offset must not exceed 2mm MAX .080"

Gauge Side of Rail Head

Finish grinding of the gauge side of the head rail is performed as follows.

- Grind the gauge face of the weld flush with gauge face of the parent (old)rail.

When the rail has cooled to ambient temperature check the alignment of the gauge face as follows:

- Place a 36” straight-edge on the gauge face of the rail with the weld at the midpoint.
- Check that both ends of the straight-edge are in contact with the gauge face.
- Inert a taper gauge between the straight-edge and the rail gauge face.
- At no point along the length of the straight-edge should the gap exceed 0.015 in.
- If a horizontal offset exists between rails in tangent track:
  - Grind the weld flush with the “narrow” rail.
  - Grind the “wide” rail so that the offset is gradually introduced as per Table X up to a maximum of three (3) feet from the weld.
- If a horizontal offset exists between rails in a curve:
  - Grind the weld flush with the “narrow” rail.
  - Grind the “wide” rail so that the offset is gradually introduced as per Table X up to a maximum of three (3) feet from the weld.

  Note: Maximum offset must not exceed 0.040"

- If rail head flow (lip) has been removed from head worn rail for a short distance to perform a weld:
  - Grind the weld flush with the parent (old) rail.
  - Grind the rail head flow so that the offset is gradually introduced as per Table X up to maximum of (3) feet from the weld.

Field Side of Rail Head

The field side of the rail head is finish ground asfollows:

- Grind the weld flush with the field faces of the parent (old) rail.
- Place a 36” straight-edge on the field face with the weld at the midpoint.
- Insert a taper gauge between the straight-edge and the field face of the rail head.
- At no point along the length of the straight-edge should the gap exceed 0.015 in.
- If a horizontal offset exists between rails in tangent track:
  - Grind the weld flush with the “narrow” rail.
  - Grind the “wide” rail so that the offset is gradually introduced as per Table X up to a maximum of three (3) feet from the weld.

- If a horizontal offset exists between rails in a curve:
  - Grind the weld flush with the “narrow” rail.
  - Grind the “wide” rail so that the offset is gradually introduced as per Table X up to a maximum of three 3feet from the weld.

  Note: Maximum offset must not exceed 1/8” (0.125 in.).
- If rail head flow (lip) has been removed from head worn rail for a short distance to perform a weld:
  - Grind the weld flush with the parent (old) rail.
  - Grind the rail head flow so that the offset is gradually introduced as per Table X up to a maximum of three 3 feet from the weld.

Web Collar and Base

Finish-grind the web collar and base as follows:

- Grind rail web and fillets smooth on both sides to within 1/16” of the original contour.
- Do not undercut rail metal.
- Do not introduce shear drag.
- If shear gouge into rail metal occurs, the weld is defective and must be removed from track.

For Roller or out of track welding, Finish-grind base faces as follows:

- Grind base faces flush with therails.
- A slight (1/16”) radius can be applied to both the top and bottom of the rail base edge, so no sharp edges remain.

Table: “X” offsets & Taper length.

OFFSET		TAPER LENGTH (T) INCHES			
X (inches)	Approximate Fractional Equivalent For Maximum	VERTICAL OFFSET	HORIZONTAL OFFSET		
			GAUGE		FIELD
			FACE	CURVE WEAR,	FACE, CURVE WEAR, FLOW LIP
0.010		6	6	6	6
0.011 - 0.020		12	12	12	6
0.021 - 0.030	1/32	18	18	18	6
0.031 - 0.040		24	24	24	6
0.041 - 0.050		30	30	30	6
0.051 - 0.060	1/16	36	36	36	6
0.061 - 0.125	1/8			36	6
0.126 - 0.188	3/16			48	12
0.189 - 0.250	1/4			60	12
0.251 - 0.313	5/16			72	18
0.314 - 0.375	3/8			72	18
0.376 - 0.500	1/2			72	24

VII Post Weld Inspection, Testing, and Marking

Post weld inspection and testing includes the following.

- Visual inspection
- Finished alignment check
- Chart recorder
- Magnetic Particle inspection

The final step in the EFB welding process is to mark the weld information on therail.

Visual Inspection

All finished welds must be visually inspected for imperfections and discontinuities that might compromise the integrity of the weld.

Finished Alignment Specifications

Finished alignment is checked after the rail has returned to ambient temperature.

Finished alignment specifications are the same as the pre-weld alignment specifications.

Vertical (running surface) and horizontal (gauge and field side of rail head) alignment verification procedures are identical to pre-weld alignment procedures:

- Place a 36” straight-edge on the rail with the mid-point at the weld.
- Insert a taper gauge between the straight-edge and the rail.
- Determine the maximum gap.
- At no point along the length of the straight-edge should the gap exceed the specified maximum.
- If a weld does not meet the finished alignment specifications, it must be removed and the rail re-welded.

Vertical (Surface) Tolerances at Ambient Temperature:

Maximum Vertical Offset:	0.060 in.
Maximum combined vertical offset and crown:	0.060 in.
Dip Camber:	None
Horizontal Tolerances at Ambient Temperature:	
Maximum gauge side horizontal offset, measured 1” from the EFB weld upset edge:	0.060 in.
Maximum combined gauge side horizontal offset and kink when kinked to gauge side:	0.060 in.
Maximum combined gauge side horizontal offset and kink when kinked to field:	0.030 in.
Maximum horizontal base offset:	0.060 in.

A weld that fails to meet these specifications is considered defective. It must be removed and the rails re-welded.

Chart Recorder Readings

The welding chart is reviewed after each weld to ensure that the following welding parameters have been met:

a. No current interruption occurred in last 1-1/2” of travel prior to upset.
b. Upset stroke greater than or equal to 1/2” and less than 3/4”.

If any one of these parameters is not achieved, the weld is considered defective and must be removed.

* Exceptions must be made for low consumption welds.

Magnetic Particle Inspection

Welds will be magnetically tested for imperfections, on a random basis, for a quality control measure and recorded on a daily weld report, at a minimum frequency of 1 out of every 10 welds per shift.

Magnetic testing is performed at a rail temperature of less than 700° F (371°C) with a Magnaflux portable Y-6 yolk (dry powder) or other suitable device capable of AC or DC power.
To aid the magnetic particle inspectors in evaluating the quality of rail welds, the following inspection procedures are to be followed:

- All butt line indications are to be cut out.
- Indications showing off the butt line (light and fuzzy), should be passed as acceptable, and a notation made on the inspection record.
- Indications outside the butt line, up to 1/8" in length are acceptable noted in the weld inspection record.
- Indications outside the butt line over 1/8" in length are considered defective and must be cut out and re-welded once. If a similar indication recurs after re-welding, the disposition of the weld will be made by the welding inspector
- All of the above will be left to the judgment of the welding Inspector.

Marking of Completed Electric Flash Butt Welds

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 ball point paint stick.
Each completed EFB weld is identified with the following information:

- In-Track EFB Welder Equipment Designation and Number
- Welder unit number, operators Initials.
- Consecutive weld number(Welding Units begin the year with Weld #1)
- Date (Month, Year)
- Rail temperature at time of welding.
- Amount (in inches) of rail added / removed (closure welds only).

All welding information must be properly recorded following CWR procedures.

Print this information legibly and in the order and at the locations specified in GO Transit Track Standard document section 7.1.6.

2. *The 13 steps* Thermite Welding

Overview

A successful thermite weld can be seen as 13 separate steps that must be done in a specific sequence:

1. Job Preparation:
    a. Use a standard checklist to ensure that you have all the necessary tools, materials equipment and information before you leave for the weldsite.
2. Site Preparation:
    a. Evaluate the general condition of the site.
    b. Correct any situations which create a potential fire or safetyhazard.
3. Track Preparation:
    a. Secure the rail so that it doesn't move during joint preparation, alignment and welding.
4. Rail-end Preparation:
    a. Inspect & prepare the joint to a condition acceptable for thermite welding.
    b. Remove all overflow metal, both gauge and field side, at the rail head by grinding to ensure proper fit of molds and rail weldshear.
5. Rail-end Alignment:
    a. Set up the correct gap, peak (also called the 'crown' or 'vertical alignment'), horizontal alignment, and eliminate unequal cant between rail-ends.
    b. This is a critical step where inconsistent work will lead to premature weldfailure.
6. Mold Preparation:
    a. Prepare and assemble the mold components & apply fusalpaste.
    b. Another critical area where poor workmanship will lead to welddefects.
7. Preheating:
    a. Heat the mold & rail-ends for a specifiedtime.
    b. Another area where accuracy and timing are important.
8. Charge Preparation:
    a. Inspect components for moisture anddamage.
    b. Assemble the crucible & charge.
9. Pouring:
    a. End the preheating at the correct time.
    b. Position the crucible centered over the mold.
    c. Ignite the charge & monitor the pour.

10. De-molding & Shearing:
    a. At a specified time after the pour, de-mold, shear and removedebris.
11. Hot Grinding:
    a. Grind the weld close to the railsurface.
    b. Blend the gauge & field surfaces to matchparentrail.
12. Cold Grinding:
    a. Grind the weld flush with the rail to blend with the running surface.
    b. Accuracy during hot & cold grinding contribute to weldreliability.
13. Finishing:
    a. Inspect, document & tag the weld.
    b. Restore the track components to standard (spike pattern, anchors, tamping, ballast, etc,)
    c. Clean the area of OTM, garbage, weld molds, etc.
    d. Clear the track.
    e. Cancel the track protection.

Step 1: Job preparation

Checklists

Consumables checklist

- ☐ Tube clay cement
- ☐ Fusal paste
- ☐ Ignition fuses
- ☐ Gasoline & oil for power tools
- ☐ Sufficient propane & oxygen
- ☐ Weld kits (2 boxes) per weld
- ☐ Three spare kits (per day)
- ☐ Tie plugs or plugging glue compound.
- ☐ Spare rail fasteners, tie plates & pads
- ☐ Spare closure rail (weight, type, length)
- ☐ Cutting disks
- ☐ Grinding wheels
- ☐ Soap Stone Paint stick markers
- ☐ I.D. tags & adhesive
- ☐ Forms, manuals, protection documentation

Hardware checklist

- ☐ Mold clamp
- ☐ Mold jackets (2)
- ☐ Base plate (2)
- ☐ Slag basin
- ☐ Crucible fork
- ☐ Ensure you have all the hardware required by the supplier to complete the weld

Hot tip!

Storage life of materials is two years or may be less in areas of high humidity. Storage must be in a dry area.

Pre & post-heating equipment

- ☐ Preheating unit
- ☐ Burner & support stand
- ☐ Regulator
- ☐ Air & propane hose (Use only T grade hose or ULG propanehose)
- ☐ Turbo torch
- ☐ Approved ignition device
- ☐ Torch
- ☐ Post-heat box
- ☐ Heat retarding blanket or shield
- ☐ Inline gauges and flashback arrestors

Safety equipment checklist

- ☐ Welder's goggles with clear and/or #5 lenses
- ☐ Face shield with clear and/or #5 lenses
- ☐ Welder's gloves
- ☐ Leggings with shin guard protection
- ☐ Hearing protection
- ☐ Respirator
- ☐ First aid kit with Burn Kit
- ☐ Fire protection equipment
- ☐ Manufacturer's Safety Data Sheets
- ☐ Contact information for local Fire and Emergency response
- ☐ Grinding, sawing and welding spark shield
- ☐ Welding umbrella or protective cover tent

Power tools checklist

- ☐ Rail saw
- ☐ Impact wrench (optional)
- ☐ Hydraulic rail expander (required is a 120 ton puller)
- ☐ Weld shear
- ☐ Profile grinder or utility grinder
- ☐ Hand grinder for riser removal grinding
- ☐ Hydraulic hand tamper

Hot tip!

T-grade hose is required for all propane and is designed for multi fuel gas use.

Hand tools checklist

- ☐ Adjustable wrench
- ☐ Track wrench
- ☐ Lining bar
- ☐ Claw bar
- ☐ Sledge hammer
- ☐ Spiking maul
- ☐ Hot cut chisel
- ☐ Adze
- ☐ Hammer
- ☐ Rail positioner
- ☐ Clip applicator
- ☐ Anchor applicator (if required)
- ☐ Tamping bar
- ☐ Shovel
- ☐ Wedges
- ☐ Wire brush
- ☐ I.D. tag stamps
- ☐ Cutting torch
- ☐ Tools to fix power tools
- ☐ Rail alignment equipment: alignment beam, rail raisers, decanter, positioner, gauge rods (optional)
- ☐ Paint marking stick

Measurement tools checklist

- ☐ Welder's straight edge, 1m (3 ft) for finish grinding (magnetic adjustable straight edge for the alignment process is preferred)
- ☐ Taper & rail wear gauge
- ☐ Rail thermometer or pyrometer
- ☐ Stop watch
- ☐ Tape measure
- ☐ Temperature measurement equipment (Temp gun 1100ºF max, contact pyrometer, or various temp sticks, 400, 450 (required), 600, 700, 900)

Information checklist

- ☐ Track protection
- ☐ All required forms

Step 2: Site preparation

When you first get to the job site, certain things must be done before you remove a single tool from the welding truck:

1. Check for safety hazards:
   a) moisture, snow or frost in ballast
   b) slippery conditions
   c) multiple tracks
   d) obstacles
   e) traffic near level crossing
2. Check for fire hazards:
   a) dry grass, brush, wood chips
   b) wind direction
   c) flammable material
   d) combustible rail lubricators
3. Make sure the area immediately near the weld or disposal hole is free of any form of moisture!
4. Digging a disposal hole is not recommended. Account the high risk of buried wires and cables, or other restrictions. The preferred method of disposal is a waste disposal bin or container and carried away to proper waste bins or scrap areas.

Caution!

Check for underground cables before digging!

5. If necessary, update your job briefing so that:
   a) everyone knows about all hazards
   b) each person is assigned responsibilities: (safety watch, fire watch, first aid, etc.)
6. Position firefighting equipment nearby and readily available foruse
7. Wet down any dry/flammable material

Hot tip!

- Check for safety & fire hazards!
- Update your job briefing and risk assessment!
- Do not wet down the area immediately near the weld or disposal hole!

Step 3: Track preparation

1. Verify line & surface
2. Place thermometer on rail or check rail temperature
3. Ensure rail type, weight and wear is compatible with weld kit. (Vertical offset must not exceed 5 MM) See table 1 on page 17-43.
4. Verify that the gap is no closer than 100mm (4”) from tie
5. Remove ballast for 100mm (4”) below the gap
6. Make sure you have a clear walkway to your waste disposal area or bin
7. Tighten anchors for at least 15m (50ft) each direction from gap
8. Remove fasteners for 1 or 2 ties to each side of the gap
9. Reference marks and match marks must be made in accordance with the GTTS
10. Check that the shear & grinder are operational and fit the rail

Hot tip!

It is critical that all anchors or fasteners are tight and the track secured. If the rail moves during the weld process:

a. The gap will change and the rail-ends will not be heated correctly!
b. The fusal paste around the molds may crack causing a run-through!

Step 4: Rail-end preparation

1. A gap must not be positioned over a tie nor closer than four inches to a tie.
2. **Chrome alloyrail (CR) is not allowed to be welded, if found report to supervisor to have removed from track.**
3. 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 weld)
4. Verify that any drilled holes are further than 100mm (4”) from the rail-end and deburr holes when possible. Closely inspect for any signs of cracking or damage. Dye Penetrate test if necessary.
5. Rail-ends must always be cut with a rail saw
6. Verify that rail-ends are cut square and perpendicular with a tolerance 3mm(1/8in).
7. Clean each rail end with a wire brush for at least 100 – 150mm (4 – 6 in). Flame clean if necessary to ensure all dirt, oil, grease, paint or other foreign material is properly cleaned and removed. Lightly grind clean if needed.

8. The weld area is defined as 0.5 m (18 in) to either side of the gap.
9. Cadweld or pin brazed bonds must be removed by grinding only. All copper must be ground to ensure it is adequately removed.
10. Remove all overflowed metal (lip) on both the gauge and field side of the ball by grinding to ensure proper mold and rail weld shear fit.

Hot tip!

The rail-ends must:

11. always be cut with a rail saw (torch cut rail ends are not allowed to be welded);
12. be square and perpendicular within 1/8 inch;
13. not have been previously welded by gas or electric welding;
14. not be welded if rail end batter is present and cannot be cut out;
15. when the gap is saw cut, the removed sliver must be dye

penetrate tested. Otherwise, a defective weld may result!

Step 5: Rail-end alignment

Alignment can be one of the most difficult and critical procedure in any thermite welding process.

1. In the alignment step, there are 4 sub-steps to correctly align the rail-ends for a thermite weld:
    a) Gap
    b) Peak (also known as vertical alignment)
    c) Horizontal alignment
    d) Unequal cant between rail-ends
2. The steps must be done in that order

Eyeballing the weld

1. Before beginning the alignment procedure, you must assess the general level of the roadbed looking for problems such as:
    a) Hanging ties;
    b) Low joints.

Hot tip!

If you have hanging ties or a low joint, surface the area before continuing with the alignment procedure!

2. 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
3. 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 gaugeside

4. Look to see if the peak of the rail-ends is:
    a) level;
    b) high;
    c) low;
    d) unequal;

Figure16-1

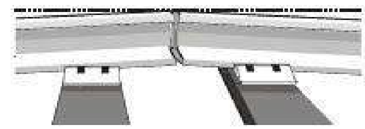


Figure16-2

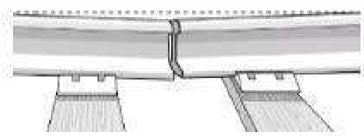


Figure16-3

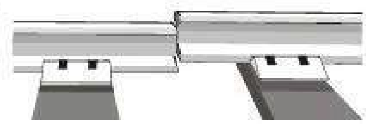


Figure16-4

5. And finally, see if the horizontal alignment is:
    a) in,
    b) out,
    c) in-line.

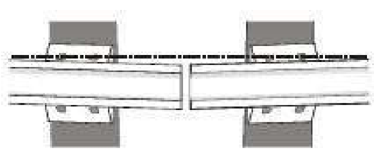


Figure16-5

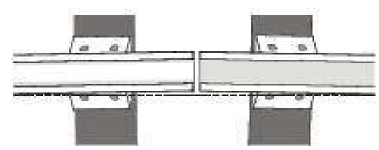


Figure16-6

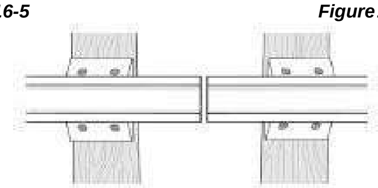
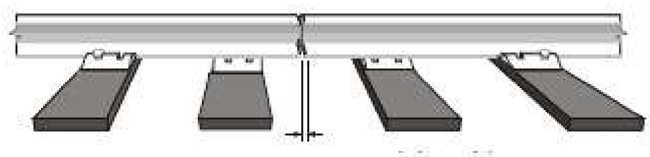


Figure 16-7

6. Eyeballing the rail gives you important information on:
    a) What rail movement will be necessary to align therail-ends;
    b) Where to position the wedges, spikes & track jacks to achievealignment.

Gap

7. Measure the gap at both sides of the rail head &base.
8. The standard gap weld can only be: Minimum 1” (25 mm) to maximum 1 1/8” (28 mm) for standard 1” gap welds.
9. If using a rail puller to achieve proper gap. All Rail Puller Safety Procedures found in Chapter 4 must be followed.



Minimum 1 to maximum 1 1/8 inch.
Note: extra preheat for 30 seconds may be required at 1 1/8 inches

Figure 16-8

Caution!

Never add or remove steel to the rail length unless otherwise directed as it will affect the stress-free temperature of the rail.

Peak (Vertical Alignment): Wood ties

1. Tap in 1 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.
2. For safety reasons alignment plates are preferred over wedges and are recommended when using the rail puller.

Tip:

Adze any plate-cut ties to help position the wedge.

3. Place a welder's straight-edge across the gap centered on the running surface. The clearance between the end of the straight edge and the running surface is how you measure the 'peak.'
4. Taking into consideration what you saw when you eyeballed the rail ends…and what the straight edge indicates…adjust the wedges until you have the correct peak at both ends of the straight edge;
5. or…adjust the peak using a 'rail raiser', if available.
6. 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, the track jacks must remain in place until the weld has cooled below 700ºF (389ºC). (Example: when leveling track, while welding switches out of track.)
7. Check the peak or crown with a Starrett taper gauge. For 122# or smaller (5 ½" base rail or smaller) 0.65 to 0.70 thousands, and for 122# or larger (6" base rail or larger) 0.70 to 0.75 thousands.

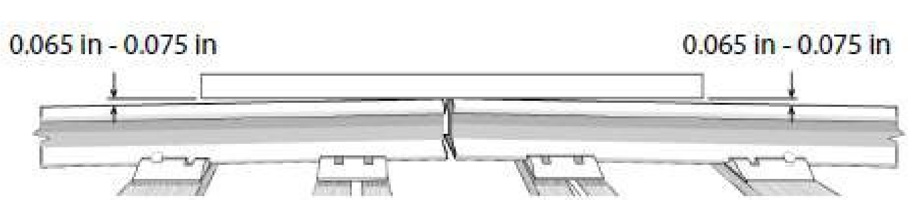


Figure16-9

Caution!

8. Do not ‘hump’ the track! Raise rail hold down spikes by 1 inch or remove elastic fasteners!
9. Never step on the rail during alignment.
10. Don’t step on the ties that are supporting the weld crown or alignment until 5 minutes after the pour.
11. Rail movement & vibration must be avoided from the finish alignment process through the weld solidification process and until 5 minutes after the pour is completed. Caution must be taken when welding in close proximity to road crossing with traffic and adjacent tracks.

Horizontal alignment: Wood ties

1. Check both sides of the head, web and base for the entire length of the straight edge across both rail-ends.
2. 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.

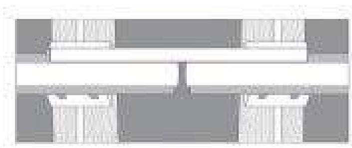


Figure16-10

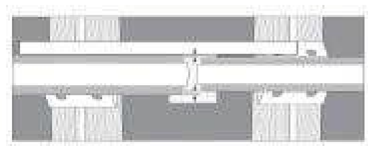


Figure16-11

3. Taking into consideration what you saw when you eyeballed the rail-ends…and what the straight edge indicates…determine which rail is out-of-line…and to which side (gauge/field).
4. Move the out-of-line rail back into alignment using the tie plate. This is done by driving a spike straight down, at least half-way into the tie, against the outside of either the gauge or field side of the tie plate under the out-of-line rail.

Caution!

5. Do not hit the rail with the hammer! Move the rail with the tie plate.
6. Do not drive the spike in at an angle. It will cause the tie plate to ride up on the spike!
7. Check the horizontal alignment with a straight edge against the gauge side of the base of the rails across the gap.

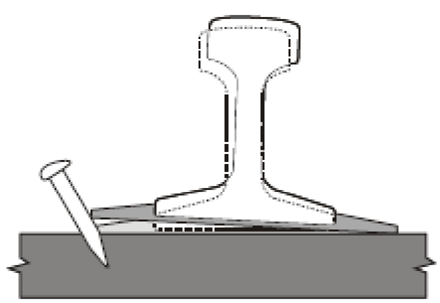


Figure16-12

8. To adjust the alignment, move the tie plate by bending the spike in slightly, then tapping it down further into the tie.

9. Repeat this procedure until the base of the out-of-line rail isback-in-line.
10. In a curve, a rail positioner or alignment plates will make the jobeasier.
11. If available, a 'rail alignment beam' willfacilitate peak and horizontal alignment on wood ties…especially in curves or at level crossings.

Unequal cant between rail-ends: Wood ties near the switch point, frog and guard rail areas

transition from flat to canted plates.

1. Check the gauge side of the heads and bases across the gap with a straight edge.
2. If the bases are aligned…but the heads are not, unequal cant between the rail-ends is present.
3. The rail with the head tipped the furthest out is the rail with excessivecant
4. Raise the spikes on that rail for a minimum of 12 – 15 ties back from the rail-end on the side with excessive cant.
5. On the same side of the same rail, place a wedge under a tie plate 12 – 15 ties back…to 'roll' the rail back into the alignment.
6. Hold a straight edge on the gauge side of the heads and tap in the wedge until the heads align.

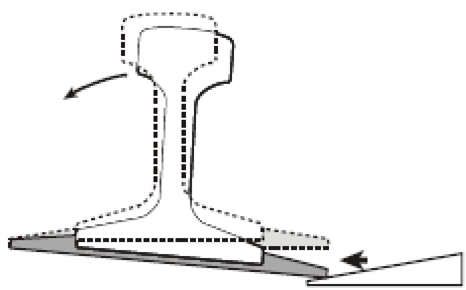


Figure16-13

7. Re-check the gap, peak, horizontal alignment, and unequal rail cant between rail-ends…and adjust accordingly.
8. In a curve, gauge rods will make the jobeasier.
9. 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.

Hot tip!

Never try to adjust unequal cant between rail-ends at the immediate weld location!

Concrete ties

1. The alignment process for rail-ends on concrete ties is different because there are no tie plates to wedge, spikes cannot be used to adjust the horizontal alignment.
2. To align the rail-ends on concrete ties, begin the same way as with wood ties
3. Eyeball the weld location.
   a) Verify the gap.

Peak: Concrete ties

1. Make sure the tie pads have been removed, and place a welder's straight edge centered on the running surface of the rail, across the gap.

2. For concrete ties, check the peak or crown with a straight edge and Starrett taper gauge. For 115# (5 ½" base rail or smaller) 0.65 to 0.70 thousands, and for 136# (6" base rail or larger)

   0.70 to 0.75.

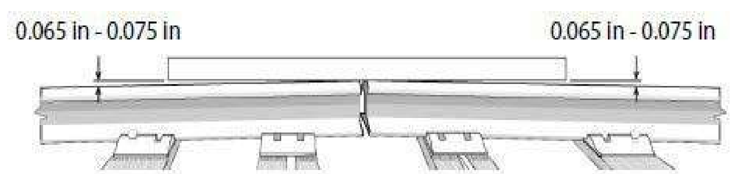


Figure16-14

3. Taking into consideration what you saw when you eyeballed the rail-ends…and what the straight edge indicates…position one wedge under the rail on the side that appears to be furthest out-of-line.
4. Do this on the first tie on both sides of the weld location.
5. Adjust the wedges until you have the correct peak at both ends of the straight edge, or…
6. adjust the peak using a 'rail raiser', if available.
7. 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.

Caution!

8. Be careful not to 'hump' the track. Remove the fasteners if necessary.
9. If using track jacks for alignment, they must remain in place until the weld has cooled down below 700ºF (389ºC).

Horizontal alignment: Concrete ties

1. 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 cast hold-down.

2. Check the horizontal alignment with a straight edge against the gauge side of the base of the rail across the gap.
3. Tap the sideways wedge in or out to adjust the base of the out-of-line rail. **DO NOT HIT RAIL**.
4. If available, a 'rail alignment beam' will facilitate peak and horizontal alignment on concrete ties…especially in curves or at level crossings.

5. A 'rail positioner' can also be used in curves to maintain horizontal alignment.

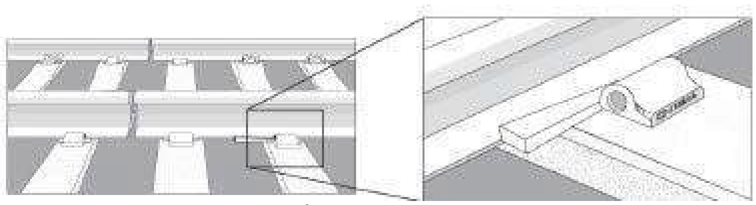


Figure16-15

Unequal cant between rail-ends: Concrete Ties

1. Check the gauge side of the heads and bases across the gap with a straight edge.
2. If the bases are aligned, but the heads are not, unequal cant between rail-ends is present.
3. The rail with the head furthest out is the rail with excessive cant.
4. On the side with excessive cant, remove the rail clips one at a time, working away from the rail-end.
5. If the heads are not aligned after removing six rail clips, tap in a wedge under the rail base 12 to 15 ties back on the same side of the same rail to 'roll' the rail back into alignment.
6. Re-check the gap, peak, horizontal alignment, and unequal cant between rail ends and adjust.
7. If available, a rail canter placed four ties back from the rail end can be used instead of a wedge.

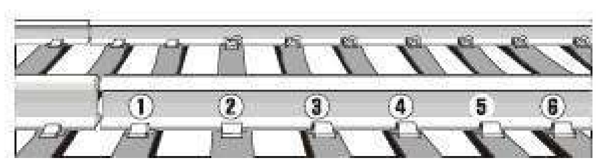


Figure16-16

Hot tip!

8. An incorrect gap can result in a poor bond between the rail ends!
9. Incorrect peak means the running surface will be too high or low when the weld cools. This causes wheel impacts!
10. Poor line will result in irregular gauge!
11. When possible, roll rail in to maintain gauge.
12. Unequal cant between rail-ends will promote fatigue weld failure through twisting or rotation!
13. Removing track jacks to early will result in a misaligned weld!

Step 6: Mold preparation

1. Protect mold from moisture and are not exceeding 2 years of shelf life.
2. Verify weld kit contents are the correct size for the rail you are welding including, offset basebrick if needed for vertical offset 3mm or greater. (See Table 1 page16-43)
3. Rub side molds on rail for tightfit.
4. After rubbing molds, ensure to remove all mold sand from rail ends and weld area of molds.
5. New Hybrid molds must not be rubbed into rail for fit. Care must be taken not to remove or tear packing felt strips from molds while installing.
6. Make sure side molds don't extend below the bottom of the base when dry fitting to the rail.
7. 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
8. Squeeze clay cement in grooves on the base brick no more than the thickness of a pencil.Too much could smear into weld fillet causing a defective weld.
9. Mold plate retaining screws on high side of rail.
10. Center base plate and brick with equal gaps on all four corners. Make sure rail plate hooksare not bent, causing the base brick fillet to be offset to one side.

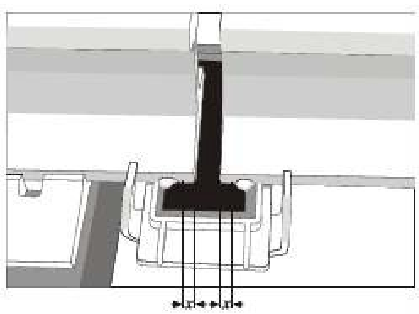


Figure16-17

11. Tighten retaining screws snug, but do not over tighten.
12. Recheck alignment with straight edge. This is the last chance before installing side molds.
13. Place side molds in jacket. Make sure that the mold shoes and jackets are not bent or warped and securely fit the molds.
14. Place side mold with spout on low side of rail.
15. Ensure side molds on the base plate and centered on gap.
16. Clamp jackets but don't crack molds
17. Recheck all corners and side of mold to ensure molds did not move or get twisted away from the rail while tightening the mold clamp in place.
18. Cover the top of the mold opening.
19. Smear a thin layer of packing mud around the entire mold rail mattingsurface.
20. Back up the thin layer with a larger bead of packing mud.
21. Place packing mud on the overfill drain, spout and clamp thread to protect hardware from leaking molten steel.

22. Line slag basin with dry sand or crushed crucible cap
23. Place box of dry sand or pan to protect the area under the molds if there is a presence of moisture of frozen ballast conditions.

Hot tip!

- Rotate your material stock ensuring molds and crucibles are not exceeding 2years.
- To center 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 thesame.
- Check the alignment after the base plate is clamped on. This is the lastchance!
- Cover the mold with a piece of cardboard to prevent anything from fallingin!
- Too much fusal paste will not dry properly and will cause moisture defects! Too little will dry & and crumble, promoting a run through!
- Rail movement and vibration must be avoided from the finish alignment process through the weld solidification process until 5 minutes after thepour.

Step 7: Preheating

Preheating with the air Blower process

1. Note and record the railtemperature.
2. Position and adjust the burner and its supportstand.
3. Angle the nozzle to the side to facilitatelighting.
4. Start the preheating motor.
5. Open the supply valve(s) to:

Mixture	Air	Propane
Air/propane	3 to 6 psi	6-12 psi depending on the hose length

(It is important to maintain 6 inch flame height above the mold)

Tip:

Since conditions may vary between trucks and equipment, or, if the tanks are fill level is low or the contents is cold, you may have to increase the fuel pressure to achieve the proper preheat rail temperature of 450ºF on all four corners of the base.

6. Ignite the nozzle with a torch and reposition it.
7. Adjust the air/fuel supply for sound & flameheight.

Mixture	Flame Height
Air/propane	6 inches
Oxygen/propane	18-24 inches

8. Start the preheating stop watch only after the flame has been properly adjusted!
9. The preheating period must be timed according to rail size and wear.
10. Check that the heating color on the 4 groove tops in the mold is orange.
11. Start the stop watch.
12. Place the diverter plug on the edge of the mold to heat.
13. It is the welder's responsibility to monitor the entire preheating process.
    a) Once the preheating starts, you must constantly monitor the preheating processes to ensure that all the rail ends are not melted and there is no breakdown of the molds. (**IF THE RAIL IS MELTED YOU MUST START OVER**).
    b) For eye protection, a minimum number 5 lens or face shield must be worn when monitoring the preheating process.
    c) Achieving uniform and proper color of the rail ends (center of the Rail Web & Base: Yellow/Orange). The true color of the rail ends can only be observed with the torch removed.
    d) All minimum times must be achieved. Additional time may be required depending on weather conditions and rail size. Use a 450°F tempilstik 2 -1/2 inches from the rail ends to test the rail for proper preheat. Laser temperature guns are not allowed for this reading as the radiant heat reflection from the preheating will give false indications.
        a) When performing compromise welds, the pre-heat times will be the time for the larger rail section (care must be taken to not melt the smaller rail section).
        b) The preheat time must not exceed 8 minutes, or mold damage could occur.

Hot Tip!

- Preheating must be done to ensure the rail temperature reaches 450ºF at the outside edge of the molds on the base of the rail next to the base plate hooks.
- Don't forget to heat the diverter plug on the edge of the mold…where you won't forget it!
- Do not force the diverter plug into the gate!

Centering the flame

1. During the pre-heat, make sure that the flame is burning in the mold…not just above the mold gates.
2. At the same time, verify that the flame is directed straight down into the mold.
3. Ensure the heating color on the four groove tops inside the mold is the same.

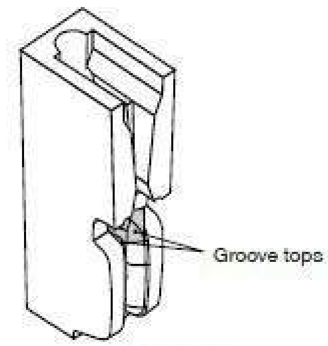


Figure16-18

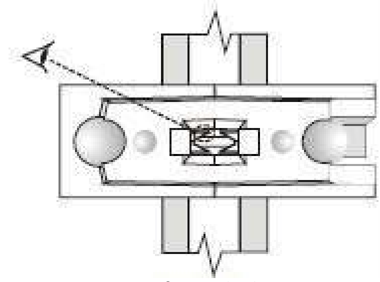


Figure16-19

Oxy-propane preheating for Railtech Boutet & Orgo-Thermite welding processes

Preheating is an operation of major importance to the successful completion of the thermite weld. Its function lies in the elimination of residual moisture from the molds and to increase the temperature of both rails and themolds.

It is essential that all preheating equipment is in proper working order to successfully complete the preheating processes.

Welding hose:

Recommended for both pre-heating processes:

a) Type “T” welding hose is required for all Oxy-Propane heating and flamecutting.
b) Oxy-Propane hose shall be 3/8” diameter and shall not exceed 100’ inlength

Preheat burners:

Recommended for bothprocesses;

Torch Body	Burner	
Victor HD 310 C	Victor TWN 5	
Hesa US Thread orifice Smith	SKV-5, 22 Smith TWN 5	
Mixture	**Oxygen**	**Propane**
Oxygen/propane	65 psi	15 psi

Working pressures at the torch head:

Recommend for:

Oxygen 65 psi

Propane 16 - 34 psi

a) It is important to check pressures before each preheat,
b) Ensure tanks are full enough to complete the entirepreheat.
c) Make sure to watch your pressures during cold weatherconditions.
d) The use of flash arrestors may require higher tank gauge pressurereadings.
e) All pressure settings must be at the torch head using inlinegauges.

Burner height above rail head:

Railtech Boutet: 1" gap welds Orgo-Thermit: 1" gap

welds

a) Burner height shall be checked, at a minimum of once per day, prior to preheating the first weld.
b) The burner must be straight and not lined to the gauge orfield.

Torch alignment:

Preheating equipment shall be aligned for each weld to ensure that it is centered along the rail and in welding gap of the molds. The burner aligned such that itis:

a) In line with the vertical axis of the rail (not pointing to the field orthegauge).
b) Vertically straight (at a right angle to the base of therail).
c) Burner tip is perpendicular to the ground (not angled up ordown).

Lighting the torch:

The propane valve and the oxygen valve on the burner shall be opened approximately 1/4 turn. The burner is then lit with a striker. The oxygen valve is then opened to approximately 7/8" long.

a) Oxygen and Propane pressures are checked to assure proper settings (65 psi oxygen, 15 psi propane).
b) Check the burner to ensure there are no clogged orifices (if dirty, the torch must be shut offand cleaned).

Preheat times:

Preheat time starts after you adjust the flame and fine-tune the torch alignment. A stop watch is the easiest and most accurate way of performing this task. The time is only a reference and proper rail end color and achieving 450ºF on all four corners of the base must be reached.

	Rail 122# and over	Rail 122# and smaller
	Time (minutes)	Time (minutes)
Railtech Boutet	6	5
Orgo-Thermit	5 to 7	4 to 6

a) Once the preheating starts, you must constantly monitor the preheating processes to ensure that none of the rail ends are melted and there is no breakdown of the molds.(IF **THE RAIL IS MELTED YOU MUST START OVER**). Achieving uniform and proper color of the rail ends (center of the Rail Web & Base: Yellow/Orange). The true color of the rail ends can only be observed with the torch removed.
b) For eye protection, a minimum number 5 lens or face shield must be worn when monitoring the preheating process.
c) All minimum times must be achieved. Additional time may be required depending on weather conditions and rail size. Use a 450F tempilstik 2 1/2 inches from the rail ends to test the rail has been properly preheated. Laser temp guns are not allowed for this reading account of the radiant heat reflection from the preheating will give false indications.
d) When performing compromise welds, the pre-heat times will be the time for the larger rail section (care must be taken to not melt the smaller rail section).

Do NOT turn down the propane pressure on torch prior to removing it from the molds (this will cause the heating torch to turn into a cutting torch and will melt the rail ends)

The diverter plug:

a) The diverter plug must be dried before placing it in the molds. This is done during the final preheating of the rail ends.
b) After the pre-heat is completed and the torch has been removed, ensure that the molds have not been damaged and no foreign objects have fallen into the molds.
c) Place diverting plug gently but snug. (**Do not tap.**)

Step 8: Charge preparation

1. Set up the crucible in a dry and level location close to the work area.
2. Check the charge bag for signs of punctures or moisture.
3. Inspect the crucible for any damage or debris, removing any loose sand.
4. Verify that the tapping thimble is in place and securely seated, not loose.
5. Remove the charge I.D. tag & attach it to the welding report form (the batch number and date are required for all reports).
6. Re -inspect the charge bag for any signs of damage (rusty or loss of material) from puncture or open bag prior to pouring the contents into the crucible.
7. Stir the charge by hand and make a mound in the center (if using the new start weld ignition system, the charge must be flat, not mounded up).
8. Insert an ignition fuse and cover the crucible.
9. 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, we may need the packing information on the mold or crucible boxes. Make sure you record the charge bag batch number and the date. It is required for all TIS reports.

Hot tip!

Always verify that:

10. the crucible is not exceeding shelf life of 2 years.
11. the crucible is clean, free of defects with no cracks!

12. the thimble is securely in place!
13. the charge bag is sealed and dry…before opening!

Step 9: Pouring

1. Put on welder's goggles or face shield (min #5 shade lens) and welder'sgloves.
2. At the proper temperature (450ºF on all four corners of the base), remove the burner nozzle from the mold.
3. Place the diverter plug snug into the top gate
4. Carefully place the charged crucible center on the molds (so equal amounts on both riser holes are visible).
5. Light the ignition fuse on the hot mold by lightly touching it to the mold riser hole, not rubbing. Care must be taken to not chip or knock any mold sand particles into molds.
6. Insert the ignition fuse into charge a maximum of 25mm(1in).
7. New startwel igniters are approved foruse.
8. Replace the crucible cover.
9. Tap time begins when the charge ignites and stops when the pour begins.
   Normal tap time is 15 to 35 seconds. **Anything longer or shorter means the weld is to be considered defective. The weld must be protected and must be replaced ASAP.**
10. When the slag stops pouring, start the stop watch.
11. After igniting the charge, ensure everyone is moved to safe distance. Clear the weld area by at least a minimum of 40 feet. View the tap and pour, remaining in the clear for 1 minute, until the reaction and pour are complete.

Hot tip!

- Short tap time results in high aluminum content because the charge is not dissolved. Long tap time results in the rail ends cooling down causing shrinkage in the rail. (Normally found in the head and web areas of the rail.) Report all tap times less than 14 seconds or longer than 35 seconds, to the welding Supervisor. You will need the crucible number on the box and the charge batch number and date. **<u>This weld must be considered defective and removed.</u>**
- When the igniter is placed too deep in the charge, it will not burn properly, trapping slag in the weld instead of allowing it to separate and rise to the surface and pour into the slagpot.
- **Welders and other employees must move to a safe place a minimum of 40 feet away after the charge is ignited for a time of 1 minute after the pour is completed.**
- If the mold should leak, leave the site immediately! NEVER pour water on molten steel or hot weld debris. Use dry sand to cover.
- Rail movement & vibration must be avoided from the finish alignment process through the weld solidification process.
  - Don't hit, step on, or move the same rail being welded.
  - The weld solidification occurs after 5 minutes have passed from the end of the pour.
  - Note any out of the ordinary movement on the weld report (working next to road xing, train going by on adjacent track).

Preheater Shutdown

1. While the crucible is being positioned and the charge ignited, shutdown the preheater by:
    a) first shutting off the fuel supply;
    b) then stopping the compressor.

Step 10: Demolding & shearing

Nothing is started until 5 minutes after the pour is completed.

1. Make sure the shear is ready!
2. Remove the slag basin and crucible.
3. Remove the mold clamp, mold jackets.
4. Score the top of the mold with a hotcut.
5. Using a demolding tool, or a sledge, to push the top of the mold into a shovel & place in a dry waste disposal area bin, box or barrel.
6. Push riser down just enough to allow profile grinding. Approx. 60-45 degree angle. Avoid knocking them off.
7. Remove any dry fusal paste from the running surface. Never strike the rail with hot cut or other tools in attempt to remove moldmaterial.

Shearing at 6 ½ minutes after the pour (+/- 30seconds)

8. Shear the excess weld material & place it in a dry waste disposal area, bin, box or barrel.
9. Bend the base risers over so they are clear of the profile grinder. Bend the riser down to approximately a 60º-45º angle just enough to allow grinding the top of ball. The rise helps control the cooling process and must not be removed until the weld has cooled below 900ºF (483ºC). The outside risers may fall off if bent too far, which is normal. Try to avoid if possible.

Danger!

10. Carry the slag basin level so that hot weld material will not spillout!
11. Never dispose of hot weld material in water, snow or on frozen ballast!
12. Do not place a hot slag basin on a concrete tie!
13. Do not empty the contents of the slag basin until it has cooled for at least 15 minutes!

Hot tip!

- Demolding; nothing is started until after 5 minutes from end ofpour!
- Shear at approximately 6 ½ minutes, (+/- 30 seconds from end of pour). This depends on your rail size and wear. Make sure the molten steel is not wiggling (like water spiders)!

Step 11: Grinding of the weld

1. Put on personal protection equipment:
    a. Face shield, goggles,
    b. Hearing protection,
    c. Respirator (recommended),
    d. Leggings.

2. Grind weld metal to 0.8 mm (1/32 in) above rail steel. This is NOT the final finish grind. It is getting close while allowing all other finishing work to be completed on time and temperature limits.
3. Grind contour radius flush or blend-in.
4. Grind gauge and field side flush or blend-in.

Rough grinding

5. Put on all required personal protective equipment.
6. Make sure you have firefighting equipment available and ready for use.
7. Check grinding stones and equipment prior to use.
8. 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.
9. Rough grinding is completed when the excess weld metal is reduced to approximately (0.030) thousands of an inch above the rail surface. Grinding only the weld area and not the parent rail steel (stay on the weld).
10. After the railhead has been rough ground, the gauge and field faces may be rough ground to within (0.015) thousands of an inch above the rail surface.
11. Crown wedges or alignment plates/jacks must be removed 20 minutes after the pour to allow the weld to return/reduce to normal vertical alignment.
12. The base plate and risers shall be removed when the weld reaches a temperature of 900ºF (483ºC) (this is about 22-25 minutes after the pour).
13. All base risers must be ground flush with the weld collar. This will ensure weld quality, and any sharp edges removed to prevent premature weld failure. Note: the only exceptions are in areas between switch point and stock rails, and toe and heal of frogs where the hand grinder will not fit.
14. During cold weather (temperatures below 40ºF (5ºC)) the weld must be covered with cooling blanket or box until the weld has cooled below 900ºF (483ºC) (see winter welding procedures).

Hot Finish Grind: Above 600ºF

It must be understood that the vertical crown will continue to reduce until the weld has cooled to ambient temperature. If over ground when hot, this will result in a low weld.

15. Finish grinding of the weld shall be performed after the above has been completed and the weld area is below 900ºF (483ºC) and above 600ºF (316ºC).
16. “Bluing” of the rail or weld surface shall NOT be permitted below 600ºF (316ºC).
17. Finish grind the weld to leave the weld (0.005-0.007) thousands high measured at the weld heat lines on each side of the weld, not at the end of the straight edge.
18. Grind the weld only and don’t dig holes in the parent rail steel.
19. Grind the required tapers of the head, gauge, and field faces if vertical or horizontal offset is present.
20. Grind radiuses on both the gauge and field corners to match existing rail contours.

How close?

21. When rough grinding, it is important to leave at least 0.8mm (1/3 in) of the weld metal on the running surface above the rail steel. **Reminder** this is not your final finish grind, it is getting the weld close to allow all other work to be completed at temperature and time limits.
22. If you grind the weld metal flush with the rail steel when the weld is still hot, above 900ºF (483ºC), you will have a low weld when it cools.
23. Remove the crown alignment wedges or plates at 900º approx. 20-25 minutes after the pour to allow the weld to cool to level.
24. If track jacks were used to lower rail-ends, they can be removed when the weld has cooled below 700ºF 372ºC. This is approx. 35 min after the pour depending on weather conditions, rail size and wear (example: when welding switch panels out of track). This is not your rail crown alignment jacks.

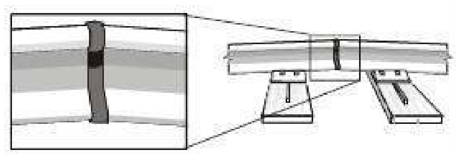


Figure16-20

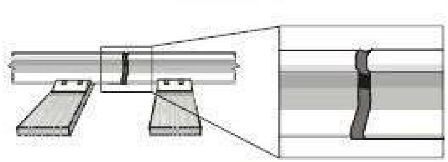


Figure16-21

Hot tip!

- Keep your distance from the parent rail steel. Don't dig holes into the parent rail steel. Use your straight edge for all finish grinding.

Step 12: Cold grinding

Cold Finish Grind: Below 400ºF

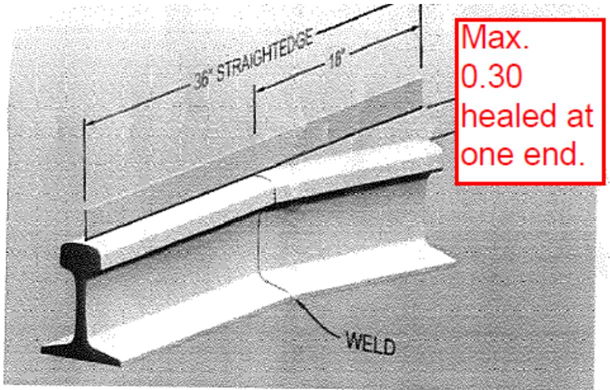
If the weld cannot be finish ground above 600ºF (316ºC), no finish grinding will be allowed until the weld has cooled below 400ºF (222ºC) (this is normally around 50-60 minutes after the pour).

1. "Bluing" of the rail or weld surface shall NOT be permitted below600ºF.
2. Finish grind the weld to leave the weld a maximum of (0.015) thousands high to (0.000) low. Measured with a taper gauge at each end of a 36" straight edge, centered at 18", on the weld.
3. Grind the weld only. Don't dig holes in the parent rail steel.
4. Grind the required tapers if necessary of the head, gauge, and field faces if vertical or horizontal offset is present.
5. Grind radiuses on both the gauge and field corners to match existing rail contours.
6. Make sure the base risers have been removed and ground flush withthe weldcollar.
7. Cold grind the weld metal flush to the rail surface, and blend-in where necessary.

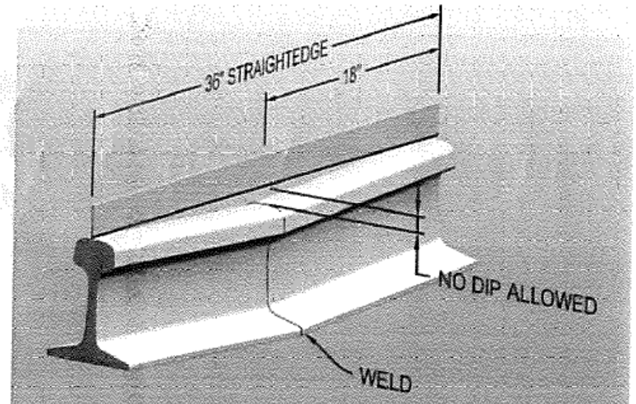
Hot tip!

- Take your time. Do not 'blue' the weld!

Completed Weld Finish Tolerance:



Finish tolerance 0.0 to 0.15 High. Maximum 0.30 healed at one end of 36" straight edge.



Finish tolerance 0.0 Low no dip allowed. Anything greater than 0.30 low is unacceptable.

Step 13: Finishing

1. Visually inspect the weld. Use the straight edge ensuring the weld you leave is in compliance.
2. Tamp 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.
3. Plug or glue all wood ties and replace all rail fasteners and/or insulators.
4. Clean up area picking up all weld waste material and properly dispose of it.
5. Load tools, thermometer, etc. You bring it, you take it. This includes picking up all OTM, bars, and rail. If you have no means to load rail, it must be rolled out of the normal walking area of trainmen.
6. The required information must be identified on a welding tag (reference GO Transit Track Standard section 7.1.6) or written in 2" lettering with paint marker on gauge side of rail web 3' from weld, (the month, year, weld number, welder ID).
7. Complete the welding documentation.
8. Inspect entire work area for any signs of smoke or smoldering material. Leave fire watch if necessary with adequate water supply.
9. Clear all equipment and personnel from the site.
10. Cancel track protection once you are in the clear.

Exception conditions

Variations in the standard welding procedures

There are situations where rail condition, different types of metallurgy, or even temperature will require variations in the standard welding procedures.

Most common are:

- Partly worn rail where the difference in the wear of the head width and height results in an uneven surface on the head, gauge or fieldside
- Cold weather conditions

∆ Head-hardened or chrome alloy rail **<u>– Chrome alloy rail CR. must not be left in track.</u>**

- The use or rail expanders.
- A freeze-up (when a charge does not pour).

Worn rail

1. In the case of unequal head width, the solution is to:
   a) Align the base and web of the rail.
   b) When grinding after the weld, blend the field & gauge side to match. The greater the face wear, the longer the taper required. Use a straight edge to ensure a smooth transition.
2. In the case of unequal rail height, the solution is to:
   a) Align the running surface and offset the height difference in the base of the rail. A straight base plate is allowed up to, but not exceeding a 3 mm offset.

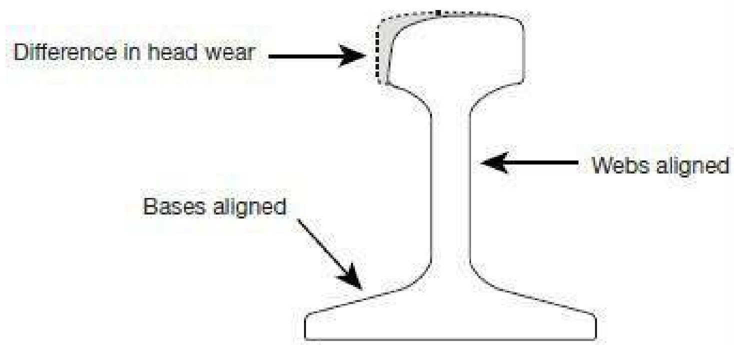


Figure16-22

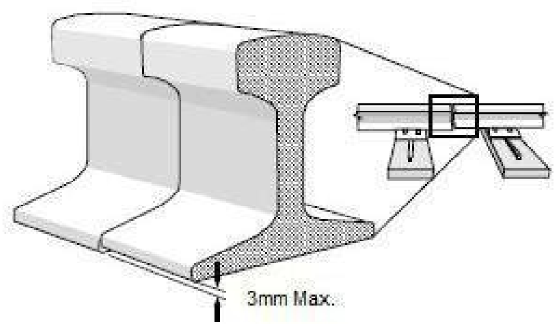


Figure16-23

Difference in rail height greater than 3.2mm (1/8in)

There are limits to the acceptable difference in the height of the two rail-ends.

1. The difference in the height of the rail heads cannot exceed 5mm.
2. If the difference is greater than 3mm but less than 5mm, use the appropriate step joints or compromise kit.

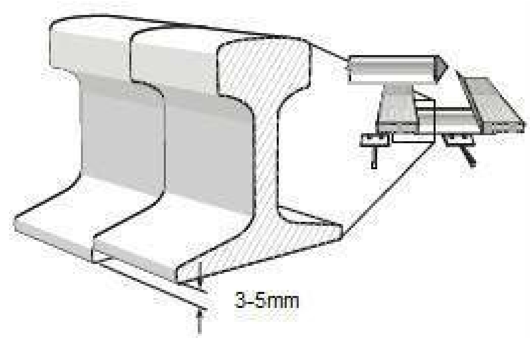


Figure16-24

TABLE 1
MAXIMUM ALLOWABLE VERTICAL RAIL BASE OFFSET

THERMITE WELDS	100 Lbs or Smaller	112/115 Lbs	132 / 136 / 141 Lbs
Straight / Standard Thermite Kit, or Kit with equal wear.	0.125" (3 mm)	Equal wear or up to 3 mm vertical offset. Straight weld kit.	Equal wear or up to 3 mm vertical offset. Straight weld kit.
Greater than 3 mm up to 5 mm vertical offset			
If Vertical Base offset exceeds 1/8'' (3 mm) a sloped base plate must be used.	Not allowed	115 new / 1/4" wear (6mm) Weld kit.	132 New / 1/4" wear 136 New / 1/4" wear 141 New / 1/4" wear **132 / 141 Multi - Use Kit**
Rails with greater than 5 mm vertical offset must have a transition rail cut to match vertical offset rail wear.			

Flash Butt Welding	100 Lbs or Smaller	112/115 Lbs	132 / 136 / 141 Lbs
	0.125" (3 mm)	0.125" (3 mm)	0.125" (3 mm)
Greater than 3 mm up to 5 mm vertical offset			
**2 mm ball offset must be taper ground up to 36'' **	Not allowed	Split the offset 3 mm in the base, 2 mm in the ball.	Split the offset 3 mm in the base, 2 mm in the ball.
Rails with greater than 5 mm vertical offset must have a transition rail cut to match vertical offset rail wear.			

Compromise Thermite Weld Kits

Are NOT allowed on Main lines and sidings which:

1. Have speeds above class 2 track.
2. Carry more than 10 MGT per year,
3. Carry passenger trains,
4. Are designated as a hazmat (DG) route

Approved Compromise Rails must be used for all other conditions

TABLE 2
APPROVED COMPROMISE WELD KITS
The following compromise kits are approved for use on GO:

Weld Kit	Allowable Lines		Allowable Vertical Base Offset
	All CN Lines	Lines Less than 10 MGT per Year	
112/115 lbs. to 136 lbs.		✓	0.67" ± 0.125" 17 mm ± 3 mm
112/115 lbs. to 132 lbs.		✓	0.48" ± 0.125" 12 mm ± 3 mm
112/115 lbs. to 127 lbs.		✓	0.375" ± 0.125" 10 mm ± 3 mm
100 lbs. to 112/115 lbs.		✓	0.625" ± 0.125" 16 mm ± 3 mm
90 lbs. to 112/115 lbs.		✓	1" ± 0.125" 25 mm ± 3 mm
90 lbs. to 100 lbs.		✓	0.375" ± 0.125" 10 mm ± 3 mm

Compromise welds between sections utilizing the same standard kit (i.e. 112 to 115 lbs.) may be made as long as the vertical base offset is within the tolerance shown in Table 1 for a Standard Thermite Kit.

Thermite Welding Weather Restrictions:

Hot thermite weld material has the potential to become explosive whenever it comes in contact with moisture. Under winter conditions, the source of moisture may be in the form of rain, snow and/or frost in the ballast. It is imperative that both CN and manufacturers' procedures for welding be followed at all times. In addition, the following precautions MUST be taken when thermite welding in the presence of rain, snow and/or frost. **In no case, must thermite welding be performed when the temperature is below 5ºF (-15ºC).**

1. Thermite Welds are recommended to be performed in dry weather conditions.
2. Thermite welding in light moisture conditions is permitted, if and only if, the weld area, welding material (charge, molds, crucible, and waste material), and the finished weld can be protected from moisture. The use of a welding umbrella or other devise isrecommended.

3. When thermite welding in light moisture conditions, the thermite weld must be covered immediately after shearing until the weld cools below a temperature of 900ºF (483ºC) .If the weld area cannot be protected from the moisture, welding operations must be suspended.

4. Thermite welding in heavy moisture conditions such as rain, sleet, blowing snow and temperatures below 5ºF and -15ºC is **ABSOLUTELYPROHIBITED.**.

5. Additional preheating and slow cooling requirements for working in adverse weather conditions are identified in the table below:

Rail Temperature	Weather Conditions	
	Clear	Wind, Rain, or Snow
Above 40ºF / 5ºC	* Air Cool 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).
	* A weld cooling cover is not required	* Leave cover/ blanket in place until the weld has cooled below 900ºF 483ºC. (This is approximately 20-25 minutes after the pour)
Between 5ºF and 40ºF / -15 ºC and 5ºC	* Prior to the application of the molds, preheat the rail head web and base to a temperature of 100ºF 37ºC for a distance of 3' on both sides of weld gap.	
	* Complete weld and unmold 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 900ºF 483ºC. (This is approximately 20-25 minutes after the pour)	
Below 5ºF /-15ºC	* NO THERMITE WELDING IS PERMITTED	

6. It is the welders Responsibility to determine if thermite welding can be performed safely during adverse weather conditions.

Winter thermite weldingprecautions:

7. A minimum of a 10' radius must be cleared of snow around the weld area. When this is not practical due to embankment constraints, snow must be cleared to at least the edge of the ballast section, along with clear walkway to the waste disposal area.
8. A hydraulic rail puller MUST be used on all closure welds.
9. Rail pullers will not be removed until the weld has cooled below 700ºF (372ºC). (applies in all conditions)

10. It is recommended to 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. It may be necessary to heat the ballast with a torch in order to facilitate removal.
11. After igniting the charge, ensure everyone is clear of the weld area by at least 40 feet, and remains in the clear for 1 minute after the pour is complete. (applies in all conditions)
12. All preheat and tear down times must be strictly adhered to. Note that a minimum of 5 minutes are required after the pour is completed before the removal of slagpans, crucible and normal demolding begins. (applies in all conditions)
13. A dry location must be secured to place the waste material (it is recommended to use a steel drum or rack on the back of a truck for disposal of the weld waste). (applies in all conditions)
14. The slag pan/basin must not be immediately emptied. It should be placed on a dry, level surface and allowed to cool for a minimum of 15 minutes after the pour is completed, and only then emptied in a dry location. (applies in all conditions)

Safety is everyone’s number one priority whenever thermite welding. Extreme caution must be exercised to prevent injury and assure weld quality.

Chrome Alloy rail CR, out of track!!!!

1. “Do not weld Chrome alloy rail. If Chrome alloy rail is found, contact track supervisor to arrange removal of rail”

Post-weld procedure: Rail expanders

1. In the event that you are using rail expanders, you can only remove them once the rail temperature has dropped below: 700ºF (372ºC)

Emergency procedure: Freeze-up of Crucible

One **rare and potentially dangerous** situation that you may encounter is a freeze-up of crucible…a condition where the charge ignites, but the weld doesn’t pour out within a minute. Normal tap time is between 15-35 seconds from the time of the ignition of the charge material until the crucible pours. If the normal tap does not pour, there is a bypass thimble that will tap the crucible at 90 seconds. This is in line with the riser hole and will pour into molds. DO NOT attempt to remove the crucible once the charge has been turned to molten steel. This crucible is extremely brittle and could crumble if an attempt is made to move, pouring liquid molten steel everywhere. This is an extremely dangerous situation which could cause severe injury up to death.

1. If this happens:
   a. Leave the crucible where it is and clear the weldsite.
   b. Return after the crucible has discharged & cleanup.
   c. **Advise the RTC and Supervisor of the problem immediately**.
   d. Cut out the weld and cut in a closure rail
2. If the crucible does not tap out the primary tap hole or bypass taphole:
   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 molds, carefully setting in theclear.
   c. Do not attempt to break it up, as there may be liquid steel that is not completelysolidified.

Hot tip Reminders; Procedures and precautions for thermite welding

1. Head bond weld nuggets of rail bonds, which could fall in and contaminate the mold area, must be completely removed by grinding prior to making thermitewelds.
2. Immediately prior to mold installation, the rail ends and surface area that will be exposed to the thermite material must be cleaned with a wire brush or a grinding wheel.
3. When the rail temperature is below 4.5ºC (40ºF), or windy or light moisture both rails must have sufficient supplemental heat applied to raise the rail temperature to at least 37ºC (100ºF). Following weather restriction procedures.
4. During the welding operation, the following precautions must be observed for handling of 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 vapor 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.
5. Molds must be centered over the weldgap.
6. During sealing of the molds, cardboard covers must be placed over the molds to prevent any foreign material from falling into the moldcavity.
7. In super-elevated track, the mold plug must be reshaped when inserted so that the upper surface is horizontal.
8. Preheating must not be interrupted and the heat shall be uniformly distributed over the rail ends. The preheat time and temperatures specified for the process employed must be adhered to.
9. Ignition must be performed immediately after preheating within 15 seconds from the removal of the torch.
10. During the pour, the crucible must be centered over the molds. After igniting the charge, ensure everyone is moved to safe distance, clear of the weld area by at least a minimum of 40 feet. Viewing the tap and pour for 1 minute, remaining until the reaction and pour are complete.
11. Should the thermite reaction or the time delay of the self-tapping thimble be abnormal, the weld must be rejected. Note: Typical tap time is between 15 and 35 seconds, deviation from this indicates a defective weld which must be removed.
12. When the pour is completed, nothing is to be removed until waiting 5 minutes after the pour is completed. This includes the slap pan, crucible, mold shoes, clamp,etc.

13. The slag pan must be removed and set in a secure dry area and note emptied until waiting 15 min. after the pour.
14. Hot welds must be protected from moisture. Apply weather restriction procedures when required.
15. Welds shall be allowed to cool normally, without induced cooling.
16. If the reaction is abnormal and the automatic thimble doesn't tap, the crucible should be left standing over the mold for 30 minutes. If the thimble releases during that time, the metal will pour into the mold, and although the weld will have to be cut out, there is no danger of personal injury. The loaded crucible should be carefully set aside and no attempt made to empty it until the metal has cooled. After cool down, the metal is easily dumped.
17. Disposing of the molten material in the slag tray must be done with care, ensuring that it does not come into contact with moisture.
18. The rail puller must not be removed until he weld has cooled below: 700ºF(372ºC)
19. Safety is everyone's number one priority whenever thermite welding. Extreme caution must be exercised to prevent injury and assure weldquality.

Thermite welding on bridges

1. Rails which require thermite welding on bridges shall be welded off the bridge wherever possible, 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) Before any welding is undertaken, a site inspection must be made to identify any hazards, and in particular, anything that may take fire. Any loose combustible material, dry vegetation, etc., must be removed. The entire structure must be examined. Do not assume that if no combustible materials are visible from above, that the bridge is fire safe. A ballast deck timber trestle is as combustible as an open deck timber trestle and must be treated as such.
   b) When thermite welding must be performed on open deck bridges, a ¼" thick steel sandbox partially filled with sand and placed between the ties is required in case of a run through. The bridge timbers will be spread by the B&S forces so that the box may be installed. Welding shall not be undertaken without the use of thebox.
   c) A thorough job briefing must be conducted with all personnel involved, to determine what will be done in case of accident or fire that may occur. Where sufficient personnel and equipment are not available to take care of any accident or fire that may occur, welding shall not be undertaken.
   d) 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) are positioned under the bridge, firefighting equipment must also be available on the bridge deck.
   e) The area around the weld must be wetted down to lessen the chance offire.
   f) When welding is complete, a fire watch person(s) shall remain at the site until the weld has cooled to ambient temperature.
   g) Compliance with GTTS document section 7.2 Field Welding isrequired.

Safety is everyone's number one priority whenever thermite welding. Extreme caution must be exercised to prevent injury and assure weld quality.

How long does it take to make a thermite weld?

"As long as it takes to safely produce a quality weld productively, following all rules and procedures."

Appendix I

Thermite Welding Task Aids

1. Thermite Welding Tasks Timeline Table

2. Thermite Welding Hot Tear Defect Avoidance Guidelines

1.0 Thermite Welding Tasks Timeline Table

Thermite Welding Reference

These are just estimated task duration time’s, additional items must be prepared prior to starting the thermite welding.

		Estimated Times	
Up-date job briefing			3
Travel to work location			10
Unload welding equipment	Fire fighting equipment must beready	5	10
Check Reference Marks	Don't add rail	0.5	2
Break down joint	Weld must be 4" from bolt hole or edge oftie	2	4
Saw cut rail gap 1" - 1"1/8"	Place Match Marks from rail to a spiked unanchored tie plate	1	3
Clean and wire brush rail ends, grind flow if needed		0.5	1
Align rail end for welding	Crown 0.065 to 0.075 for all 1" standard gap welds	2	10
Install rail puller if needed, knock off anchors or clips, per CWR charts.			5
Pull expansion out,	**Use your CWR temperature differential charts.**		3
Recheck rail alignment after pull	Crown 0.065 to 0.075		4
Pre-heat rail if cool to proper distance to 100°F	Cold weather procedures		3
Install weld molds and pack.	**Check for proper moldfit!**	3	8
Align torch in molds		0.25	1
Pre-heat rail ends depends on rail size	**SET Times from here**	6	6
Tap time **15 - 35 sec.** anything less or more than the weld must be concidereddefective.		0.5	0.5
All personal must be clear of weld by a minimum distance of 40' for 1 min. after pour is completed.			
Weld solidification	start timing when last dropstops	5	5
Start demolding weld	**5 min from end ofpour**	1	1
Knock top of weld	about 6 1/4 - to 6 1/2 min	0.25	0.25
Shear weld	6 1/2 min to 7 1/2 min	0.5	0.5
Knock risers down and top gate off		0.25	0.25
Hot grind rail ball surface to 0.030"	Grind the weld only, not the parent metal	3	3
Cover weld if below 40° F with box or heat blanket to control cooling			
Wait until weld is approx. 900°F to remove base plate and risers	**Aprox. 20 min. after pour**	8	8
Remove crown wedges or lower alignment plates		0.5	0.5
Remove base plate and Risers		0.5	0.5
Hot finish Grind weld between 900° F and above 600° F		8	8
Re-spike weld		3	3
Wait to weld cools to 700°F to remove puller	**Aprox. 35 min. after pour**		5
Remove puller			5
Apply and tighten all anchors or clips		5	8
Tamp ties under weld		3	3
Grind off risers to the wld collar, and grind the gauge and field of ball		2	2
Weld cooled to below 400°F OK to finish grind rail surface of ball if not completed above 600°F			
DON'T TAKE SHORT CUTS	**SET Times = 46.5**		
Finish grind ball rail surface 0.0 low to 0.015 high finish, "don't grind parent metal".			
Required information on rail, and inTIS.	Initials, date, weld #, rail temp, Match marks, +/- rail.	0.5	1
Load balance of equipment on truck			3
Travel to next location or setoff			10
		61.25	**130.5**

Safety is your number one goal. (Don't take short cuts)

Producing **Quality** work is your number two goal. (Follow the procedures)

Being **Productive** is your number three goal. (Have the required equipment ready to work)

How long does it take to make one thermite weld? **"Bake the cake" follow therecipe.**

As long as it takes to safely produce a quality weld productively, following GO Transit procedures.

2.1 Thermite Welding Hot Tear Defect Avoidance Guidelines

Movement during solidification; HOT Tear Failures.

Some in-service thermite weld Rail Failures ISRF (DWF) can be attributed to movement during the solidification of the molten steel within the critical 5 minutes after the pour, or movement of the rail puller prior to the weld cooling below 700 °F. The thermite welding procedures indicate that nothing is to be moved or touched within the first 5 min. after the pour. This allows the weld to properly solidify. (Example: the bread in the oven while rising and you slam the oven door “It falls.”) If there is movement, vibration of the rail during solidification the weld has a high risk of failure.

1. Train passing on adjacent track caused vibration in the rail being welded during pour and solidification.
2. Change in weather, it started raining and cooled rail temperature down caused the rail to pull back during pour and solidification. The rail puller was not used to control movement.
3. Rail puller leaked off pressure from 90 ton to 30 ton, during pour solidification, and holding time until weld was cooled below 700 °F.
4. Vibration in the rail from vehicular traffic while welding next to road crossing.

Peer to Peer communication is the key. Ask and know where the trains are before you make the pour. Protect the track from movement during the pour and solidification process of the weld; the first 5 minutes are critical. Be aware of changing conditions that could affect the quality of your weld.

- Wait until the train passes before pouring the weld.
- Stop the train traffic if possible.
- Slow down the train traffic on adjacent track to 10MPH.
- Stop road or Highway traffic.
- Protect a safe zone work area of the rail you are welding on.
- Monitor changing weather conditions. Use rail puller to hold rail during tensile force changes. (sudden rain shower)
- Inspect and monitor your equipment for leaks slippage or movement changes.
- When in doubt cut it out!

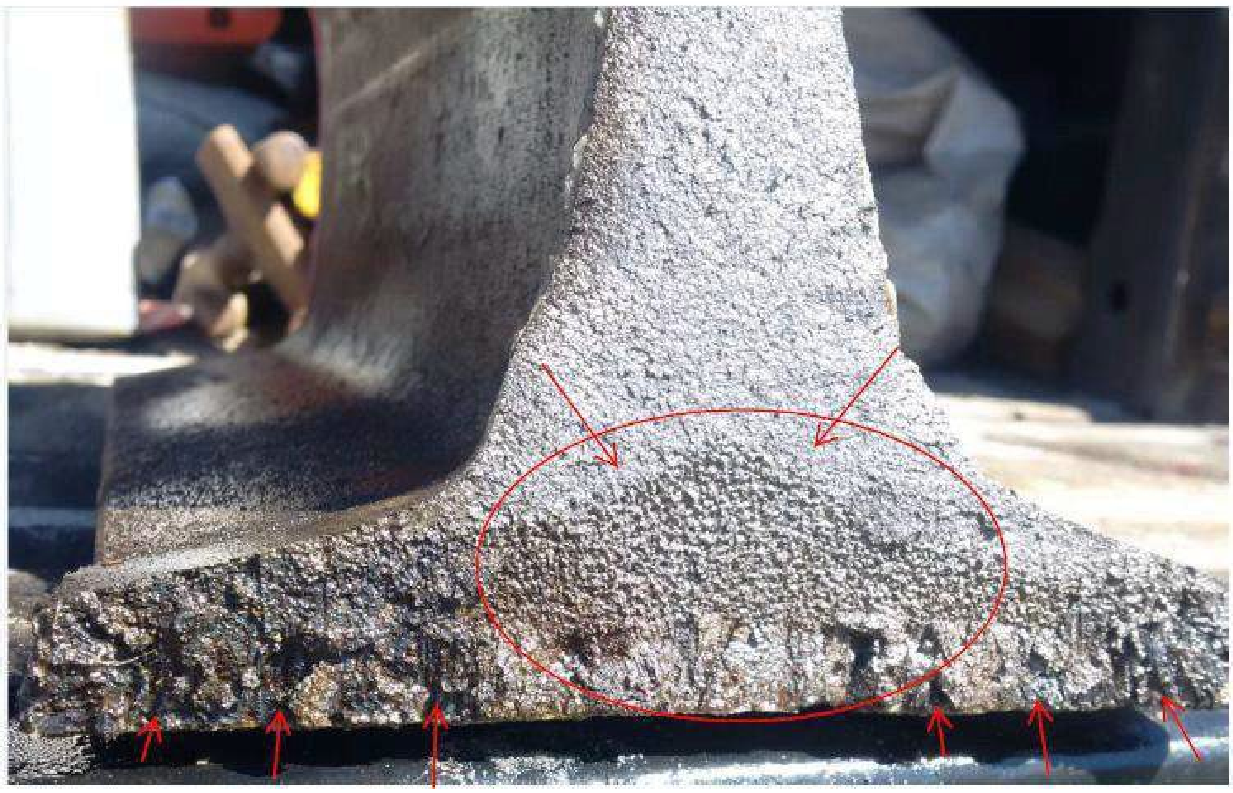
This typical Hot Tear defect will not be visible to the eye as they are internal in the weld.

If you note any movement, vibration, or change, protect the track / weld.

1. Cut it out and replace it if time and material is available.
2. Protect the weld with support bars until it can be removed from track.
3. Place 10 MPH TSO and monitor weld until support bars have been applied or weld has been cut out

of track. Some examples of failures on CN rail lines:

Bala Sub. 24.2 _5-17-16 Grain structure change and discoloration indicates hot tearing from movement.



Cause of the failure was due to the rail pulling back during or immediately after solidification of the weld. The rail had not been restricted by either a rail puller or tightening up of the rail anchors, the rain caused the rail temp to quickly drop resulting in the rail pulling back at the weld location. This resulted in the weld being put under tensile stress prior to cooling down to 700 °F which caused the hot tear to occur. In this situation with rail temperature dropping and possibility of rain, rail pullers should have been used.

St-Hyacinthe Sub. 43.3_6-10-16 Grain structure change and discoloration indicates hot tearing from movement.

Cause was a train pass on north track one minute after the dropping of the weld. Due to the condition of surfacing and the lack of ballast at the approach of the crossing on north track, the ground was vibrating heavily. The foreman put his hand on the rail on south track which they were working on, and the rail was vibrating. It was noted on the weld report that there was movement during solidification, but no other action was taken.

Yazoo Sub. 29.7_4-13-15 Grain structure change and discoloration indicates hot tearing from movement.

Probable cause is mechanical failure of rail puller bleeding off and not holding pressure. There was no indication of the rail puller slipping on the rail. The rail puller was tested and determined that the locking needle valve was getting harder and harder to lock in place, which caused damage to the valve needle allowing fluid bypass and releasing holding pressure to hold the weld in place during the solidification process. There was a CN System safety flash 2014-03 on this exact topic.

Peer to Peer communication is the key. Ask and know where the trains are before you make the pour. Protect the track from movement during the pour and solidification process of the weld; the first 5 minutes are critical. Be aware of changing conditions that could affect the quality of your weld.

Chapter 17: Air Arc Machines/Slicing Torch

Introduction

This chapter looks at two procedures available to railway welders for removing defects in metal before building-up, and for destroying 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, but are not to be employed as a substitute for grinding. Indeed, both methods must be followed by grinding in order to remove burnt surface metal, expose cracks, and prepare a smooth surface for welding. They are more efficient and faster than flame cutting as they leave no slag.

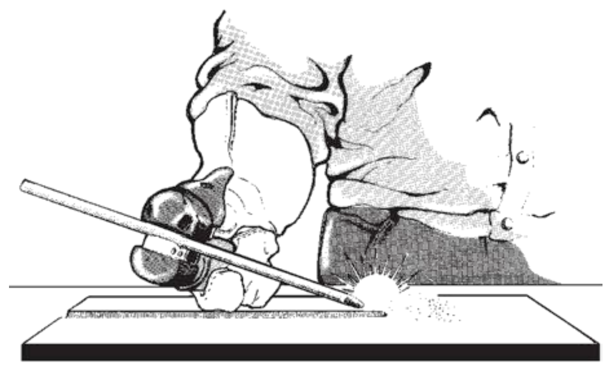


Figure 17.1

Important notes:

a) Air arc and slicing torch methods are never to be applied in the preparation of chrome and heat treated steel.

b) Advantages of using the air arc or slicing torch methods arise from savings in material and labour. When used properly, they impart low heat into the base metal, contrary to oxyacetylene cutting, and thus reduce distortion to a minimum.

c) Never use oxyacetylene cutting equipment in the preparation before welding of any track component, whether or not it is carbon steel, Hi Si, head hardened or alloy rail.

d) The air carbon arc process is designed to work as a gouging tool and does not perform as well as the arc slice method for through-cutting. Arc slicing performs well for both gouging and through-cutting. Both methods may be applied to multi-position work, including vertical and overhead.

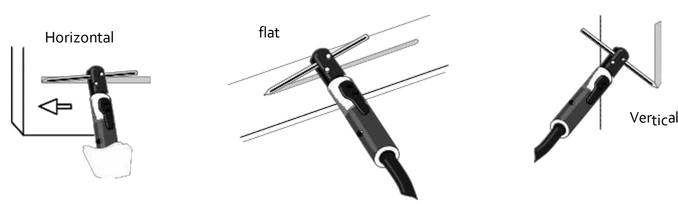


Figure 17.2

Air carbon arcmethod

Air carbon arc metal removal is a process wherein the result is accomplished by melting the base metal with the heat of an electric arc between a non-consumable carbon electrode and the base metal to be cut. As the metal melts, a jet of compressed air is directed at the point of arcing to blow the molten metal away. Air carbon arc metal removal does not depend upon oxidation and therefore works well with all metals.

Characteristics of the air carbon arc method

a) This procedure requires higher electrical current than is needed for welding metals of the same thickness and so the welding machine must be capable of supplying that extra current.

b) Compressed air may be supplied from any source: individual air compressor, cylinders of compressed air, or an "on-line" system in the shop.

c) The carbon electrode is held by a special electrode holder through, which the compressed air is ducted and directed against the arc.

d) The air stream is controlled by a push button on the electrode holder, and the air pressure delivery range is generally from 90 to 115 psi.

e) The air passing through the holder also serves to cool it.

Cuttingaccessories

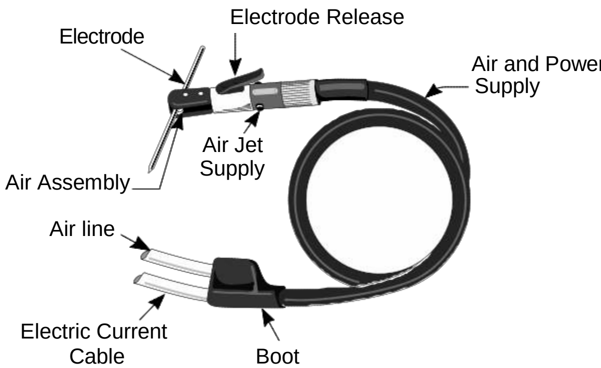


Figure 17.3

Carbon arc metal removal is performed using a special accessory connected to a welding machine and a supply of compressed air. The following illustrations show the various parts of this accessory.

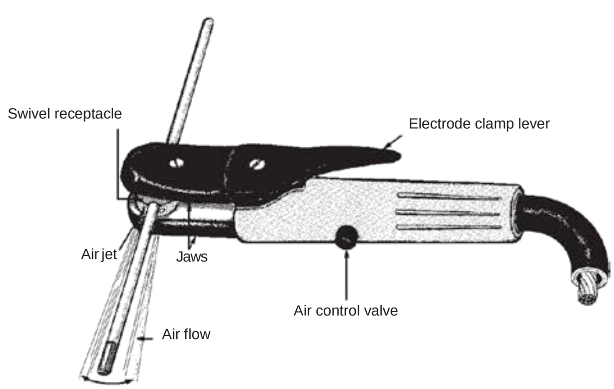


Figure 17.4

A. Electrode holder

The bottom jaw of the electrode holder contains a swivel receptacle with air jets that direct the compressed air along the length of the electrode. This receptacle has a groove that holds the electrode in place, and it can be adjusted so the electrode is held at the desired working angle.

Located on the handle of the electrode holder is the electrode clamp lever. By pressing thelever you can open the jaws and insert or remove an electrode.

The flow of compressed air is activated by pressing a button on the side of the electrode holder; a lock feature keeps the air flowing. It can be shut off by pressing the button on the opposite side of the holder.

B. Combination air hose and electrode cable

This section of the carbon arc accessory delivers electric current to the holder and the electrode, as well as compressed air to the holder.

C. Receptacle

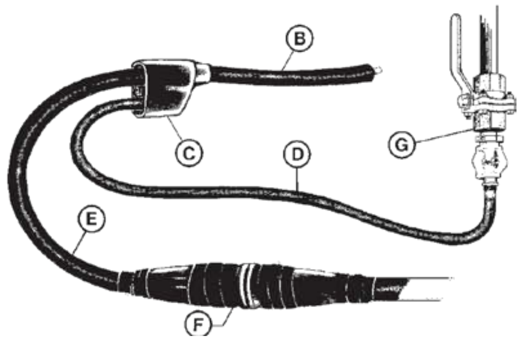


Figure 17.5

This is a rubber boot covering the junction connection of the air hose and the electrode cable.

D. Air hose

The air hose delivers compressed air from the air supply.

E. Carbon arc accessory electrode cable

This cable supplies electric current from the welding machine.

F. Twist lock connector

This is an insulated connector that joins the welding machine electrode cable to the carbon arc accessory electrode cable.

G. Air supply connection

This part connects the air hose to the air supply.

Carbon arc electrodes and welding machines

Unlike ordinary electrodes that deposit filler metal, carbon arc electrodes used by most railways have a copper coating. This coating quickly releases heat from the electrode and allows it to cool faster. A carbon arc electrode therefore wears away more slowly and lasts longer that a conventional electrode.

Figure 17.6

At GO Transit, the most commonly used diameters for carbon arc electrodes are 6mm (1/4") and 8 mm (5/16"). The diameter chosen of course depends on the size of the gouge required and the thickness of the workpiece. Keep in mind that the gouge produced is usually 3mm (1/8") wider than the diameter of the electrode.

Carbon ArcElectrode			
Electrode Diameter	Metal Thickness	Amperage Settings	
		Min.	Max.
4 mm (5/32")	13 mm (1/2" or less)	80	150
5 mm (3/16")	13 mm (1/2" or less)	110	200
6 mm (1/4")	13 mm (1/2" or less)	150	350
8 mm (5/16")	13 mm (1/2" or less)	200	450
10 mm (3/8")	13 mm (1/2" or less)	300	550
13 mm (1/2")	13 mm (1/2" or less)	450	700

Table 1

Table 1 indicates the amperage settings to be used with various carbon arc electrode diameters. As you can see, the electrode diameters that are most commonly used, 6 mm (1/4") and 8 mm (5/16"), require amperages that range from 350 and 450 amps respectively. For this reason you should use a welding machine with a minimum power capacity of 400 amps and a 60% duty cycle.

For carbon arc metal removal, you must use an AC/DC welding machine connected in reverse polarity because AC current connected in reverse polarity maintains 1/3 of the total heat in the workpiece, which makes metal removal easy.

Arc cutting

Due to the fact that some cutting operations may continue for a considerable length of time and at high current rates, precautions must be taken to avoid skin burns or eye damage. The following practices should be observed:

1. Be sure all surfaces of the skin are shielded from the arc rays. Wear approved gloves, helmet and clothing.
2. Use helmet filter lens a shade or two darker than would be used for welding with the samesize electrode (#13 lens is recommended).
3. Use a completely insulated electrode holder.

4. Stand or work only in dry surroundings.
5. Ventilation of the working space must be such that the operator is working in clean fresh air at all times. A considerable amount of fumes and gases are liberated during all arc cutting operations.
6. Fire resistant garments should be worn. Pockets, cuffs and other clothing crevices must be covered, as most arc cutting processes are accompanied by a great amount of sparkingand showers of molten globules of metal.
7. The same as with any other welding task, be sure that the working area is fireproof. All flammable objects such as wood benches, floors or cabinets should be removed from the vicinity. Also, be sure there are no holes in the floor, which would allow sparks to travel to the floor below.
8. Since the arc-air cutting process uses a higher electrical current than is used for welding the same thickness, be sure the welding machine has ample capacity for the currentneeded.

Care of the electrodeholder

1. All connections must be tight to prevent short-circuits and loss of current.
2. Blow moisture from air lines before attaching them to the cable leading from the electrode holder.
3. Be certain the electrode is firmly seated in the holder.
4. Wire-brush the contact head occasionally to maintain a clean surface and avoid poor contact.
5. Do not allow a hot electrode to touch the holder or cable.
6. This is an expensive tool. Do not abuse it.

Operating procedures

1. Adjust the welding machine and air pressure regulator according to the electrode manufacturer's instructions.
2. Insert the electrode in the holder, extending 150 mm (6") beyond the holder. The electrode end must be properly shaped. Sharpen to a conical point, then, slightly flatten the tip 90° to the electrode length.
3. The air jet disc in the holder can swivel and automatically aligns along the electrode to any angle to which the electrode is adjusted, relative to the holder in the desired workingangle.
4. Align the electrode holder so the electrode slopes back from the direction of travel. The depth and contour of the groove are controlled by the electrode angle and the travel speed. Proper speed, angle, amperage, and air pressure produces a clean, smooth cut and is recognized bya steady hissing sound.

Once the proper angle is established, you should make sure that the depth and width of the gouge remains constant as you proceed along the crack.

Gouging technique

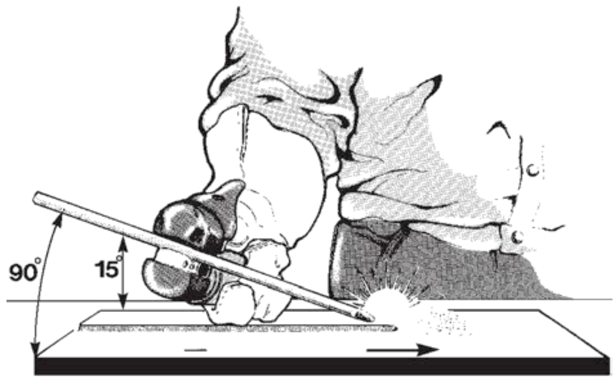


Figure 17.7- Make sure the arc pushes the molten metal ahead of the arc.

5. A steep angle and slow speed will produce a narrow, deep groove. A flatter angle and fast speed produces a wider, shallower groove. Width is determined by the size of the electrode, or by the manipulation of it in a circular or weaving motion.

Tips:

Following are some tips for achieving the depth and width of the gouge you will need for certain types of cracks.

For wide and deep cracks: use a large diameter electrode and high amperage.

For shallow, narrow cracks: use a small diameter electrode and lowamperage.

Cracks in metal parts must be gouged out so proper penetration can be achieved during welding. The depth of the gouge needed depends on the size of the crack and the thickness of the material. If a crack appears right through the material, as it does in Figure 18-7, a proper root face is needed to act as a support for the weld. As a general rule:

- For material 6 mm (1/4”) - 10 mm (3/8”) thick, the root face should be 3 mm (1/8”)
- For material 10 mm (3/8”) - 13 mm (1/2”) thick, the root face should be 5 mm (3/16”)
- For material 13 mm (1/2”) or more, the root face should be 6 mm (1/4”)
- For material 20 mm (3/4”) or more, the root face should be 6 mm (1/4”) and gouged on both sides if possible.

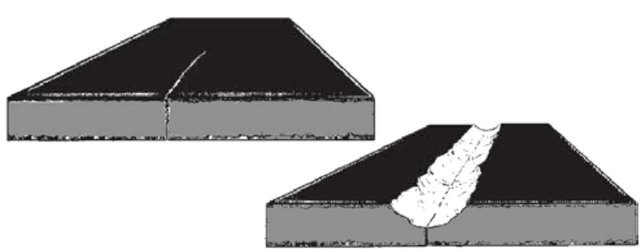


Figure 17.8

6. To avoid carbon deposits at the beginning of a groove, depress the air jet valve before striking the arc.

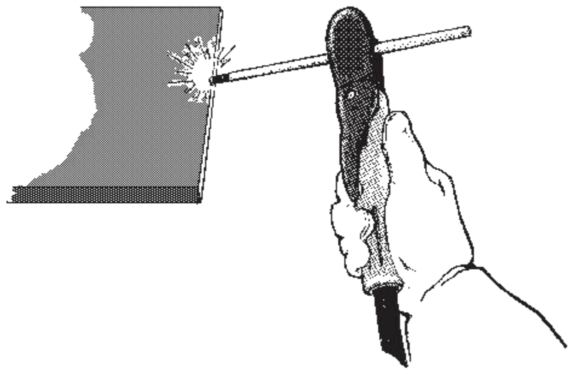


Figure 17.9 - Beginning the gouge

7. Strike an arc by touching the electrode lightly to the work then draw it back quickly, maintaining the arc and providing clearance for the air blast to sweep beneath the electrode and remove the molten metal.
8. Overheating must be prevented. Pause between passes and remove hot slag from flange-ways immediately following each pass. The burned surface must be ground smooth and relatively level to a minimum depth of 3 mm (1/8") below the gouged or cut surface, with all traces of gouging marks removed.

Beveling

The carbon arc accessory can be used to bevel edges of the workpiece.

When beveling, you must adjust the electrode to the desired bevel angle, and, at the same time, ensure that the air jets are pointed in the right direction. Using a guide like the one pictured in Figure 17-10 will help keep your hand steady so you can maintain the angle and size of bevel more easily.

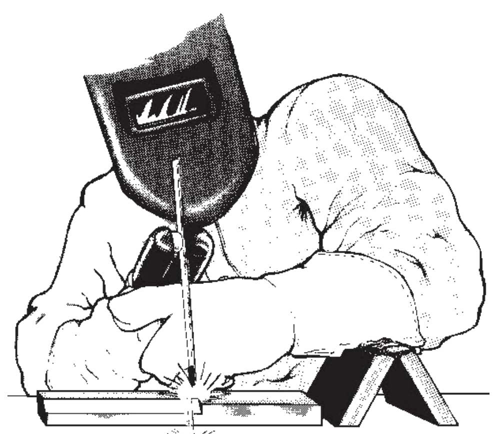


Figure 17.10

Safety

a) Pressure may cause the molten steel spray to “blow back” toward the operator. Eye protection and protective clothing (polyester clothing, torn, oily clothing is not permitted) are essential. Cutting or gouging too deeply in one pass may cause “blow back”.

b) Be certain electrode holders are completely insulated.

c) A considerable amount of fumes and smoke are given off during arc cutting operations. The workplace must be well ventilated.

d) All flammable objects must be removed from the area. Make sure that the work area is fireproof and protected by screens if required.

e) Be certain to warn others in the area of your intention to cut or gouge and the hazards of arc flash and hot metal spray. Do not direct sparks toward yourself or others.

f) Wear a welding mask with glass tinted darker (one or two shades) than for shielded metal arc welding. Because metal removal requires high amps, the arc is therefore more intense.

g) Wear ear plugs or other hearing protection, particularly in confined spaces; compressed gas used for metal removal is very noisy.

h) Always check to see where the cut piece will fall.

Electric welding and high frequency equipment

1. All power wiring to welding machines should be installed and maintained in accordance with the Canadian Electrical Code.
2. Always be sure that the power to the machine is shut off before making any repairs or adjustments, as the high voltage used for arc-welding machines can inflict severe or possible fatal injuries. For those using High Frequency Equipment, make sure you know the equipment and understand the basic principle of how it works.

   Do not play with what you don’t know.
3. **Be sure your machine is properly grounded. Stray current causes severe shock when ungrounded parts arctouched.**
4. Do not use pipelines carrying gases or flammable liquids and conduits carrying electrical conductors for grounding purposes. Be sure conductors can safely carry the ground current.
5. Never change the polarity switch nor throw the rotary switch when the machine is under load. Wait until the machine is idling and the circuit is open or you will probably damage the contacts.
6. Do not make welding current adjustments, which involve breaking the welding circuit, while the operator is welding.
7. Don’t let the electrode holder contact the welding ground; this will cause a dead short circuit on the welding generator.
8. Keep cable connection at the electrode holder tight. A loose connection causes excessive overheating.

9. Don't overload welding cables or operate with poor connections. Operating with currents beyond rated capacity causes overheating, while poor connections cause bad welds.
10. Don't work in a damp area. Keep hands, clothing and work area dry at all times.
11. Avoid contact with electrical leads, particularly when perspiring.
12. Again... never strike an arc on a compressed gas cylinder. Serious fires and explosions have been caused this way. Keep electrodes, electrode holders and other live parts away fromgas cylinders.
13. Check the condition of your helmet and hand shields for cracks. Replace defective parts.
14. Never look at the arc with the unprotected eye. Wear flash goggles with side shields atall times, even when adjusting controls, etc.
15. Be sure that helmets and hand shields are equipped with the proper type of filter plates.
16. Never strike an arc if there is somebody near you who is not protected. Use anon-reflecting screen to protect others working nearby.
17. Remember: Be sure there is plenty of fresh air from blowers, air lines or other means, while welding in closed or confined places. Never use compressed oxygen forventilation.
18. When toxic fumes from lead, zinc or cadmium bearing materials or any other substances are present in harmful concentrations, always use an air supplied respirator.
19. Do not weld in the presence of Trichloroethylene or Perchloroethylene vapors. The electric arc can break down halogenated hydrocarbons to form phosgene, which is a health hazard. Ultra-violet rays will also decompose triehloroethylene or perchloroethylene vapors at considerable distances to form phosgene in much greater amounts.
20. Never operate a gasoline powered welder where you cannot get rid of the enginefumes. Carbon monoxide will kill or seriously injure.
21. While arc-welding, wear leather welding gloves, fire resistant apron and adequate clothing to protect the skin against the heat, spatter and sunburn of the arc rays. Wool clothing is preferable to cotton, while garments made of synthetic materials and oily, torn or frayed clothing must not be worn due to their flammable nature.

Chapter 18: Principles of FlameCutting

Cutting andwelding

Safety in cutting and welding demands the following:

a) Knowledge of the process being applied.

b) Understanding the characteristics of the material being used.

c) Ability to utilize the equipment to its best advantage.

Foreword

Safe practices in the storage, handling and use of oxygen and fuel gas cylinders as well as the operation of oxygen-full gas and electric welding processes command the attention of all who are concerned in the elimination of accidents.

This section has been prepared to provide a practical list of “Do’s and Don’ts” so that we may understand the precautions which are necessary for the safety of the persons engaged in the processes of welding and cutting and for the protection of those who work nearby.

The rules and recommendations included are the result of investigation and experience. Although this section is complete for this purpose, we are aware that advancements in techniques and, new welding 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.

Storage, handling & use of oxygen, fuel gas & the operation of equipment

Oxygen and fuel gas (acetylene or propane may be used as fuel)

Compressed gas cylinders are safe for the purpose for which they are intended, but must not be abused or mishandled. Cylinders must be properly secured at all times.

The following rules should be observed when storing, handling and using cylinders containing compressed gases.

Only approved cylinders that are acceptable for transportation are marked to indicate that they comply with the Canadian Transport Commission specifications and regulations shall be considered suitable for compressed gas containers.

General rules

Storage of cylinders

1. Store CYLINDERS in assigned places where they will not fall or be knocked over. They should be protected against damage from passing or falling objects with proper valve protection caps from the supplier.
2. Do not store fuel gas and oxygen cylinders in the same compartment. There should be afire resisting partition between stocks of oxygen and fuel gas cylinders, also keep full or empty (marked) cylinders separated to avoid confusion.
3. Store and use fuel gas cylinders, valve end up. Storage area must be ventilated, as per Regulations.
4. Where cylinders are stored in the open, they should be protected from accumulations of ice and snow and from the direct rays of the sun, in locations where high temperatures prevail. Should the cylinder valve become clogged with ice, thaw with warm, not boiling water applied only to the valve. Never use a flame for this purpose.
5. Full cylinders should be used in the order as received from the supplier.
6. Per “Accident Prevention Manual for Industrial Operations” Engineering and Technology - Ninth Edition, and Canadian Center for Occupational Health and Safety: Store oxygen and fuel gas cylinders at least 6m (20 ft.) apart, or separate by a 1.5m (5 ft.) high wall with a half-hour fire resistant rating. Keep cylinders at least 6m (20 ft.) from flammable materials such as paint, oil, or solvent.
7. Do not store oxygen cylinders near excessive heat, as cylinder valves are equipped with a safety device that will blow or burst with an abnormally high pressure thus releasing theoxygen to the air. Oxygen will not burn but supports combustion and will cause oil and other similar material to burn with an intense flame.
8. When returning empty cylinders to the suppliers by freight, forward the original bill of lading promptly. Use common white chalk for indicating that cylinders are empty. Do not use soapstone, grease, crayon, or paint for marking cylinders in any way. Be sure all valves are closed.

Handling and use of cylinders

1. When moving cylinders by means of a crane or derrick, use a suitable cradle, boat or platform.
2. Keep cylinders in trolleys built for them. When not in using such a trolley to movecylinders, detach cylinder regulators and fit with valve protection cap.
3. Never use valve-protection caps for lifting cylinders from one vertical position to another.
4. Never use cylinders as rollers or supports even if considered empty.
5. Do not drop or handle cylinders roughly nor allow them to strike each other violently.
6. Do not use top of cylinders in use as a place to store tools, hose, or anything, which will interfere with quick closing of the valve (on old cylinders).
7. Do not attempt to repair or alter cylinders or valves.
8. Never tamper with the safety devices in valves or cylinders.

9. It is illegal to tamper with numbers and markings stamped into the cylinders.
10. Do not use a hammer or an improper wrench to open cylinder valves.
11. Always close cylinder valves when work is finished in accordance with the manufacturer's instructions.
12. Close valves when moving cylinders.
13. Always close valves of empty cylinders.

Valve-protection caps are designed to protect valves from damage. Before raising oxygen cylinders from a horizontal to a vertical position, be sure the cap is properly in place and hand tight, then raise the cylinder. It is not good to store fuel gas cylinders in the horizontal position. **Always use proper wrench to install or dismantle regulators**.

Oxygen cylinders

14. Always refer to oxygen by its full name "Oxygen" and not, for example by the word "air". A serious accident may easily result if oxygen is used as a substitute for compressed air.
15. Do not handle oxygen cylinders or apparatus with oily hands or gloves. Oxygen cylinders should never be handled on the same platform with oil or placed in a position where oil or grease is likely to fall on them.
16. Do not move an oxygen cylinder any distance unless the valve is securely closed and the cap is in place.

Warning:

Do not use oxygen in pneumatic tools, to start diesel engines, to blow out pipe lines, to "dust" clothing, or equipment or for head pressure in a tank of any kind.

17. Call fuel gas by its full name "Acetylene or propane" and not by the word "Gas". Acetylene is far different than furnace gas.
18. Propane Cylinders should be opened following the supplier's recommendations e.g. older type cylinders were opened 1 and one half turns, Liquid Carbonic are opened fully. Propane cylinders should be opened following the supplier's recommendations.
19. Never, under any circumstances, attempt to transfer a fuel gas from one cylinder to another, or to mix any other gas with it in the cylinder, nor to refill a fuel gas cylinder.
20. Cylinders should be kept far enough away from the actual welding or cutting operation so that sparks or flame will not reach them.
21. **Never strike an arc on any cylinders**. Serious fires and explosions can be caused this way.
22. Never use a cylinder that is leaking a fuel gas. Sometimes valves on abused cylinders become leaky.

    Test for leaks with soapy water, never with a flame.

    Fuel gas is escaping around the valve stem, close the valve and tighten the packing gland nut thus compressing slightly the packing around the stem. If this does not stop the leak, close the valve and attach to the cylinder a card stating the valve is unserviceable. Notify the supplier and follow their instructions as to the return of the cylinder.

If the fuel gas leaks from the valve even when closed, or if rough handling causes a leak at a fuse plug device, remove the cylinder to a place out-of-doors well away from any possible source of ignition. Open the valve slightly to let the fuel gas escape slowly. Place a sign at the cylinder warning anyone against coming near with a lighted cigarette or other source of ignition. When empty close valve, tag the cylinder as having an unserviceable valve or fuse plug; notify the supplier, and follow their instructions as to its return.

Leak Test Procedures

23. The system must be pressure leak tested once daily prior to use. Leak test the system, by performing the following steps:
    - With the oxygen cylinder valve open, adjust the oxygen regulator to deliver 20 PSIG.
    - With the fuel gas cylinder valve open, adjust the fuel regulator to deliver 10PSIG.
    - Be sure that both oxygen and fuel gas control valves on the torch handle are **closed**.
    - Close both the oxygen and fuel gas cylinder (tank) valves.
    - Turn the adjustment screw (“T” handle) on the regulator, counter clockwise (1) turn.
    - Observe the gauges on both regulators for 3 - 5 minutes. If the gauge readings do not change, than the system is leak tight.
    - If there is a pressure drop on any of the gauges, there is a leak in the system.
    - Use an approved leak test solution, or **oil base <u>FREE</u>** soap / water solution, (Ivory soap is oil free) and check all fitting and connections for leaks.
    - If the leak can’t be found the system must **NOT BE USED** until the system is repaired and is determined leak free.
    - If system is determined leak free, open the cylinder tank valves and proceed with your work.

Note:

All rules governing the handling, storage and use of acetylene will also apply to propane gas.

Equipment

Basic rules:

1. Keep all equipment clean, free of oil, and in good condition.
2. Avoid leaks from all cylinders.
3. Open oxygen valves slowly.
4. Purge oxygen and fuel lines before lighting.
5. Keep heat, flame and sparks away from combustibles.

General rules:

1. Never interchange fuel gas regulators, hoses, or appliances with similar equipment intended for use with other gases. The same instruction applies too propane.
2. Never connect an oxygen regulator to a cylinder containing combustible gas or vice versa.
3. **Always attach a regulator before using oxygen from a cylinder.**

4. Always attach a regulator when using fuel gas from a cylinder. If the connection on the fuel gas cylinder is not the same as on the fuel gas regulator, connect a standard adapter between them. Never use an adapter except that furnished by the manufacturer.
5. Never tighten the regulator to cylinder connections without first closing the cylinder valve.
6. Do not use blowpipe or regulators, which are in need of repairs.
7. Do not use pipe-fitting compounds, oil or grease for making connections.
8. Never use a hard, sharp tool for cleaning tips, except where such tools may be specifically recommended or supplied by the tip manufacturer. Use appropriate tip cleaners. An oversize or bell mouth orifice may lead to trouble.
9. If a regulator shows excessive creep (pressure building up when torch valves are closed), close cylinder valve and have regulator replaced immediately.
10. Torch should be shut off before being laid down for any purpose.
11. If a station hydraulic back pressure valve should freeze, do not use flame or heated object to thaw it. Only warm water or low pressure steam should be used for this purpose.

Hose:

1. Only standard hose connections with proper clamps should be used for connecting hose to blowpipes, regulators and supply stations. It is very important that all these connections be tight. Test for leaks with soapy water. Never use wire for binding hose to the hose nipple.
2. Leaks in the hose or nipple connections should be repaired at once, by cutting off the hose a few inches from the end and making new connections. Leaks in other locations can be repaired by cutting out the bad section and inserting hose connections as a splice. Leaks not only waste gas and oxygen but are a source of danger.
3. Inspect hose regularly prior to use and repair at once when needed. Leaks in hose can be detected by immersing it in water under normal working pressure. Only T grade hose is acceptable at Metrolinx-GO Transit.
4. Do not attempt to repair hose with tape.
5. Do not crimp hose to stop flow of gases temporarily as in changing torch or tip.
6. Protect the hose from flying sparks and open flame.
7. Always protect hose from being trampled on or run over. Do not leave the hose so it can be tripped over and a connection pulled off, or worse, the cylinders and equipment pulled over.
8. Do not allow the hose to lie in pools of oil or grease because these will penetrate rubber.
9. Should a sustained backfire occur and reach the hose, discard that length of hose. A backfire of this sort renders a piece of hose unsafe, because it may burn the inner walls. Flash back arrestors are used to prevent the reverse flow of gases through the torch, hoses, or regulator.
10. Exceptionally long lengths of hose should be avoided. When these must be used, care should be taken that the hose does not become kinked or tangled and that it is protected from damage. (100’ maximum length, 3/8” diameter, “T” grade hose is approved for all fuel gas)

To set up apparatus

A. To connect oxygenregulator

1. **Important:** Use no oil! Keep oxygen away from oil or grease.
2. Be sure that cylinder is secured so it cannot be accidentally overturned while in use.
3. Remove the valve protecting cap, stand at the side or rear of the cylinder outlet and open the valve slightly (crack the oxygen cylinder valve.) Then close it. This will clear the valve of dustor dirt that may have accumulated during shipment.
4. Connect the oxygen regulator to the oxygen cylinder valve, which have right-hand thread connections. Tighten the union nut with a regulator wrench, and be sure the nut is pulled up tight.
5. 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.
6. Release pressure adjusting handle on oxygen regulator by turning it to the left (counter-clockwise) before opening cylinder valve. Then open oxygen cylinder valve slowly. Allow the high pressure gauge hand to move up gradually before fully opening the cylinder valve.

B. To connect acetylene or propane regulators

1. Fasten the fuel cylinder in an upright position. If the cylinder has been laid flat for a considerable time, it should be placed in an upright position for at least twice as long as it was laying down up to 1 hour, prior to use. This is to prevent loss of fuel, damage of the equipment or fouling the flame.
2. Open the valve an instant (crack) to clear opening of particles of dust or dirt. Be surethat escaping gas is not directed toward welding or cutting work, sparks, flame or any other possible source of ignition.
3. Connect the fuel regulator (left-hand connections) to the fuel cylinder. Tighten union nutsnugly with the regulator wrench to prevent leaks.
4. Turn out the pressure adjusting screw of the regulator until it is loose (counter-clockwise) before opening the cylinder valve.
5. The older type acetylene cylinders will be opened one and one half turns. Liquid carbonic cylinders must be fully opened.
6. Never use free acetylene at more than 15lb.

C. Connecting hoses

1. Oxygen and acetylene hoses should never be interchanged; oxygen hoses are green, acetylene hoses are red.
2. New hose is dusted on the inside with fine talc. Blow this dust out before connecting to blowpipe.
3. Connect the oxygen hose from the oxygen regulator or station oxygen valve to the hose connection on the blowpipe marked “Oxygen”; tighten the connection with the proper wrenches. In the same way, connect the acetylene hose from the acetylene regulator or station hydraulic back pressure valve to the hose connection on the blowpipe marked “Acetylene”. Do not open blowpipe acetylene valve.

D. Adjusting pressures

1. Select the proper head, tip or nozzle for the blowpipe, according to the chart or table furnished by the apparatus manufacturer and screw it carefully and tightly into the blowpipe.
2. With the blowpipe oxygen valve open, turn in the pressure adjusting screw on the oxygen regulator to the pressure desired then close the blowpipe oxygen valve.
3. With cutting attachments or cutting blowpipes, open both the blowpipe oxygen valve and the cutting oxygen valve before adjusting the oxygen pressure.
4. With the blowpipe fuel gas valve CLOSED, turn in the pressure-adjusting screw on the regulator to the pressure desired.
5. If the fuel gas is supplied through a hydraulic back-pressure valve, keep the blowpipe fuel gas valve closed until ready to light the flame.
6. When a new cylinder is connected, open the blowpipe valves a sufficient length of time to purge the air from the hose, before lighting. (3-5 seconds for every 25' of hose)

E. Lighting the blowpipe

When lighting the torch and adjusting the torch flame follow the manufacturer's directions.

In general, the procedure followed in lighting an oxygen/fuel gas welding, heating or cutting torch is:

1. Open the fuel gas torch valve 1/4 to 1/2 a turn.
2. Light the flame with a friction lighter.
3. Reduce the fuel gas flow, until the flame just starts to produce black smoke around its edges, if possible open to get rid of black smoke.
4. Open oxygen torch valve slowly until desired flame is obtained.

F. Stopping work

1. When welding or cutting is to be stopped, close the blowpipe fuel gas valve, then the blowpipe oxygen valve. (Depends on the torch Manufacture. Follow the recommended practices.)
2. When the welding or cutting is to be stopped for lengthy periods the cylinder valves should be closed and the pressure released from the regulator.

G. Backfire and flashback

- Improper operation of the blowpipe may cause the flame to go out with a loud snap or pop. This is called a backfire. Shut the blowpipe valve(s) check the connections and operation then relight - possible causes: touching the tip against the work, overheating the tip, loose tip or head, dirt on the seat or by operating the blowpipe at other than recommended pressures. A reverse flow check valve is used to prevent the reverse flow of gases through the torch, hoses, or regulator.

- A flashback occurs when the flame burns back inside the blowpipe, usually with a shrill hissing or squealing. Closing the blowpipe oxygen valve first stops the flashback. Then the fuel gas valve should be closed, the oxygen and fuel gas regulators closed. When flashbacks occur, they indicate that something is radically wrong and should be investigated to determine the cause before relighting the blowpipe. A clogged orifice or incorrect oxygen and fuel gas pressures are often responsible. Flashback arrestor was designed to eliminate the possibility of an explosion in the regulator or cylinder.

Personal protection

1. Always wear goggles or face shield with suitable filter lenses when using a torch, heating, or welding tip; adequate eye protection is extremely important and must never be overlooked. (Minimum of a #5 shade lens is required)
2. When using the blowpipe wear clothing suitable for the kind of work to be done. For hand or wrist protection, leather gloves should be worn, while fire resistant apron and sleeves should be used when required. Wool clothing is preferable to cotton because it is not so readily ignited. Clothing of synthetic materials must not be worn due to their flammability.
3. Keep protective equipment dry and free of oil.
4. Take care that your own clothing is not oily, torn or frayed, and that pockets and cuffs are not open and ready to receive sparks, or hot slag.
5. Never use oxygen for ventilation - that is, never try to replace oxygen in the atmosphere that has been consumed during a welding or cutting operation - ventilate with air.
6. When toxic fumes from lead, cadmium or beryllium bearing materials or any other substances are present in harmful concentrations, always use an air supplied respirator.
7. Do not hang blowpipe with its hose on regulators, cylinders, cylinder valves, over the shoulder, or other parts of the body.
8. Do not weld or cut for at least 15 minutes after contamination of clothing with oxygen.
9. Do not attempt to light the blowpipe with matches. Use a friction lighter or stationary pilot flame.
10. Do not cut material in such a position as will permit the cut section to fall on your legs or feet.
11. The carrying of matches or other combustible material such as butane lighters, pens and combs when welding or cutting can be dangerous.
12. Do not hold torch to face to test the flow of gas.

Working on tanks and containers which have held combustibles

1. Welding of containers should be done only by personnel familiar with American Welding Society's standard practice recommendations.
2. Do not weld or cut containers such as drums, barrels and tanks, until you are sure there is no danger of fire or explosion.
3. Do not depend on your eyes or nose to decide if it is safe to weld or cut a closed container; find out what was in the container or use an explosimeter (gas detector). A very small amount of residual flammable gas or liquid can cause a serious explosion.
4. Never use oxygen to ventilate a container.

When you know the container held a gas or liquid which will readily dissolve in water:

1. Flush out with water several times and then fill with water as far as work allows, positioning container to permit introduction of as much water as possible.
2. Before welding or cutting be sure there is a vent or opening to provide for release of air pressure.

When you know the container held a gas or liquid which will not readily dissolve in water:

1. Clean out thoroughly with steam or a cleansing agent and fill with an inert gas such as carbon dioxide or nitrogen before repairing. Carbon dioxide is heavier than air and will tend to remain in the container if the opening is at the top.
2. Use steam to clean out light materials.
3. Use a strong caustic soda solution to clean out heavy oil or grease. Be careful when cleaning with steam or caustic soda - wear goggles and gloves.
4. Be sure to fill with inert gas, such as nitrogen or carbon dioxide, no matter how well you have cleaned - there may still be traces of oil, grease or other readily oxidizable material under the seams.
5. Do not clean where there is poor ventilation. Ventilation is necessary to carry away harmful or explosive vapors.
6. Do not clean where there are open flames.
7. When scraping or hammering to remove heavy sludge or scale, use a spark resistive tool and keep it wet to avoid sparks.
8. Keep your head and arms as far away from your work as possible.

General recommendations

1. Every week, disconnect the blowpipe and blow out both lines. It is important that the inside of the hose is clean.
2. When working in a confined space, always have a helper present to close the valves at source of oxygen and fuel supply and to help in case of emergency.
3. Welding in confined space requires special precautions, be sure of proper ventilation by natural means or by air fan or blower. Special clothing, preferably fire-proofed, should be worn. Respirators may be required. Only those personal that have been trained, and are qualified, shall be allowed to enter confined spaces, or ware respirator equipment.
4. Never, under any circumstances, inject fuel or a mixture of fuel and oxygen into a confined space or hole for the purpose of lighting flame from previously heated metal. If it is necessary to work in such a place, always light the blowpipe and adjust flame before inserting it into the space.
5. When working from oxygen and fuel pipe lines always replace caps after removing the hose from the oxygen valve and hydraulic back pressure valve.
6. When welding or cutting in buildings provided with wood floors, protect the floors from sparks and hot metal by an adequate fireproof covering. Have a fire extinguisher handy.

7. All hoses should be checked periodically for leaks, worn places and loose connections. To find leaks, immerse the hose in water when under pressure.
8. Use only a clean wood surface or a leather surface to clean the end of a tip, and keep oxygen flowing during this operation to prevent plugging the orifice.
9. **Periodic inspections should be made of all safety equipment.**

Other fuel gases

1. Hydrogen.
2. L.P. I Liquefied Petroleum (Propane -Butane).
3. Natural Gas.
4. MAPP Industrial Gas.

Hydrogen

Hydrogen may be used with oxygen. The resultant flame does not produce as high a temperature as the oxy-fuel gas flame; however, the oxyhydrogen flame is very clean and is recommended for welding aluminum and magnesium. Because it can be used at a higher pressure than acetylene it is also recommended for underwater welding and cutting. Since hydrogen is itself a reducing agent, this flame, if properly adjusted, minimizes oxidation. A regular oxy-fuel gas torch may be used with hydrogen as the fuel gas. Hydrogen is supplied in cylinders similar to oxygen and the pressures in the cylinders are about the same.

Hydrogen cylinders are fitted with special fittings and the regulators used on these cylinders must be provided with proper mating attachments.

Hydrogen has no odour and, with either air or oxygen, it forms a possible powerful explosive mixture.

Hydrogen connections should be checked regularly for leaks using a soap and water solution.

LP – Gas

Liquefied petroleum gases: this term has been applied to certain combinations of hydrocarbons, variously known as, butane, propane, iso-butane and pentane.

Under moderate pressure, the gases liquefy and are shipped and stored in this state, but when they are released at atmospheric pressure, at relatively low temperatures, they vaporize and can be handled and used as a gas.

In the interest of safety, the following properties of LP-Gas should be understood:

1. The gas or vapor is heavier than air.
2. The vapors or gas will diffuse into the atmosphere very slowly unless the wind velocity is high.
3. Open flames will ignite air-gas mixtures, which are within the lower and upper flammable limits.
4. Gas-air mixtures may be brought below the flammable limit by mixing with large volumes of inert gases such as nitrogen, carbon dioxide, or steam.
5. Fine water spray reduces the possibilities of igniting gas-air mixtures.

6. The vapor pressure of this fuel is greater than that of gasoline. It is safely stored only in closed pressure vessels built according to regulations and equipped with safety devices as required.
7. Liquids in open vessels will evaporate to form combustible mixtures with air, even if the atmospheric temperature is many degrees below the boiling point of the liquid.
8. The rapid removal of vapor from the tank will lower the liquid temperature and reduce the tank pressure. The rapid removal of liquid will not reduce the tank pressure.
9. The liquids will expand in the storage tank when atmospheric temperature rises. Storage tanks must never be filled completely with liquid. Refer to regulation showing filling density of storage tanks.
10. Liquid obtained from the storage tank will freeze the hands on contact, even if gloves are worn. This is due to the rapid absorption of heat by the liquid on vaporization in the open.
11. Condensation will occur in gas distribution lines when surrounding temperatures are below the boiling point of the liquid.
12. Liquefied petroleum gases are excellent solvents of petroleum and rubber products.

All rules governing the handling, storage and use of acetylene gas will also apply to LP-Gas.

LP-Gas must be stored in cylinders or tanks authorized for this purpose. There are two types of the 100 lbs. cylinders, one that is to be used at all times in a vertical position and one that is to be used 30 degrees off of horizontal.

Cylinders are identified by stampings on the top of cylinders as follows: ICC or CTC code number, water capacity in pounds, date of manufacture, ownership serial number and tare weight.

Tare weight is the weight of the empty container with valve but less valve cap. It is an essential marking to the proper filling of the cylinder. By means of the tare weight the amount of fuel in the cylinder may be determined by weighing. The total weight of the cylinder less its tare weight is the weight of the fuel alone. If a 100- propane cylinder is stamped T.W. 89.5, it should weigh 189.5 pounds when properly filled.

Natural gas

Natural gas, now piped to most communities, is an excellent fuel for certain uses. It is particularly adaptable for cutting, soldering, brazing and pre-heating. Because natural gas is delivered at a rather low pressure, injection type torches are used for cutting and general heating. Some small torches have been developed, which use compressed air and natural gas, particularly for soldering and brazing.

Natural gas piping installations, which use either compressed air or oxygen, should be protected by a water seal or a blow back valve to keep air and oxygen from backfiring into the gas supply line.

MAPP

MAPP - Stabilized methylacetylene - pro-padiene is a fuel gas sold under the trade name of MAPP. It should be noted that this fuel gas is not a mixture of calcium carbide generated acetylene with other substances but rather it is a compound of methylacetylene. The fuel has the safety and ease of handling of liquefied petroleum gas, with a heating value approaching that of acetylene.

This fuel has some advantages over acetylene when used for cutting. It is also used for underwater cutting since it may be used at pressures of over 15 psi.

All usual cutting torches may be used with the fuel. However, special tips made for MAPP gas should be used.

OXY-MAPP cutting is rapid, and liquefied slag is formed which flows away leaving a clean cut.

Introduction

Flame cutting is really nothing more than the controlled burning of metal. When iron or steel is heated to a bright red, and a stream of pure oxygen is directed against it, the metal can be seen to burn rapidly. Under the influence of this action, an oxide is formed by the chemical reaction of the oxygen coming into contact with the heated metal. This oxide becomes molten and is blown away, exposing more metal to the action of the oxygen.

How oxy-fuel gas cutting works

If only a stream of pure oxygen were used in cutting, cutting would not be possible. It is necessary to provide intense heat from an external source to keep the reaction going by keeping the metal hot and the oxide in a liquid state. For this purpose, oxy-fuel gas blowpipes are constructed to provide oxyacetylene flames for heating the metal to be cut. When the metal to be cut reaches the desired temperature, a stream of pure oxygen is blown onto the work. The stream of pure oxygen is controlled by a valve on the blowpipe, which allows passage of additional oxygen through the cutting tip in a narrow jet stream.

In a cutting operation, as the blowpipe is moved along, there successively occurs the preheating of the metal to be cut, formation of oxide by the pure oxygen reacting with the heated metal, melting of the oxide, and the blowing away of the melted oxide by the stream of pure oxygen. This exposes more metal to the oxidizing action. The successive oxidation and removal of the oxides rapidly cuts a hole or slot through the metal.

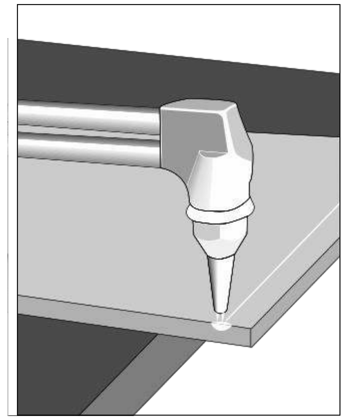


Figure 18.1

The metal at the starting point is heated to bright red, approximately 1700°F (944°C).

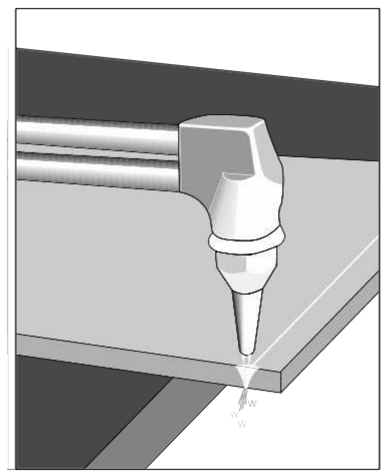


Figure 18.2

As the stream of oxygen is directed at the heated area, oxidation occurs. The pressure of the oxygen stream blows the oxidized metal away, exposing more metal to the heating process.

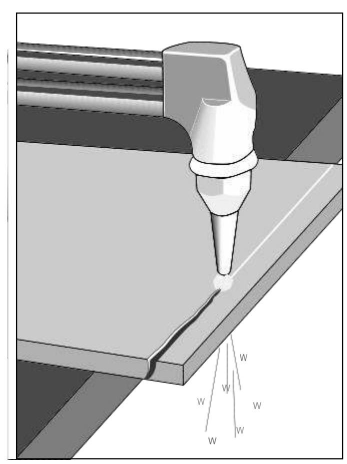


Figure 18.3

Cutting continues as the torch is moved.

Cutting of metals

All irons and steels do not cut with equal ease, since some are more resistant to oxidation than others and have certain physical properties, which may hinder the cutting action. Such properties exist in metals such as cast iron, malleable iron, laminated steels, etc.

Metals other than iron or steel, such as copper, aluminum, brass, white metal, etc., form oxides, which melt at a higher temperature than the base metal and, although it is possible to cut these metals with the use of a flux, it is a specialized process.

Preparations

Since the cutting action depends on the chemical reaction between the metal and the oxygen, it is important that the surface be clean before attempting to cut. Dirt or scale should be removed by passing a flame over the line of cut prior to cutting, or by scraping, chipping or brushing with a wire brush.

Cutting procedure for steel

The first consideration for cutting steel or any material with an oxyacetylene flame is safety.

- All connections must be leak proof.
- Combustible material must be removed from the spark line or if it cannot be removed, it should be protected by a non-combustible shield.
- If cutting is to be done on galvanized metals, enamels or bronze, etc., the fumes may have a harmful effect, and proper ventilation must be provided, or the welder should use a respirator.
- When cutting materials such as lead based paint, which produce poisonous fumes, a respirator must be used.
- Feet and legs should be protected from sparks and precautions must be taken to guard against being hit with the piece being cut off.
- Special attention is required when cutting steel under high tension or compression, such as continuous welded rail *(CWR)*. It may break free in any direction with great force.

Figure 18.4 - Watch those sparks

Clear away flammable debris within a radius of 8 m (25'). When absolutely necessary to do flame cutting inside a building, wet down wooden flooring before oxyacetylene cutting. Avoid such conditions if at all possible.

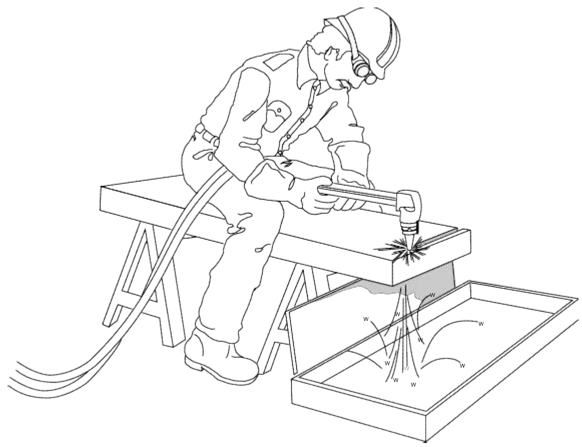


Figure 18.5 - Protect feet and legs from sparks and metal that is being cut off.

With safety of operations ensured, steps may now be taken to commence cutting. The first step is selection of the correct tip size. A great deal of the rough cutting being done by welders may be attributed to high oxygen pressure with oversized tips. For the greatest efficiency, as well as, economy in cutting, use the smallest tip possible with pressures set to the manufacturer's specifications for the size of nozzle used.

Next, correctly align the preheating holes of the nozzle in relation to the type of cutting to be done. For square cutting, that is straight through the metal at 90° to the surface, the preheat holes of the usual 4 preheat hole nozzle should be aligned with one preheat flame directly ahead of the cutting oxygen, one directly behind it, and one on either side of the cut. For bevel cutting, the holes should be aligned with two preheat flames on each side of the line of cut.

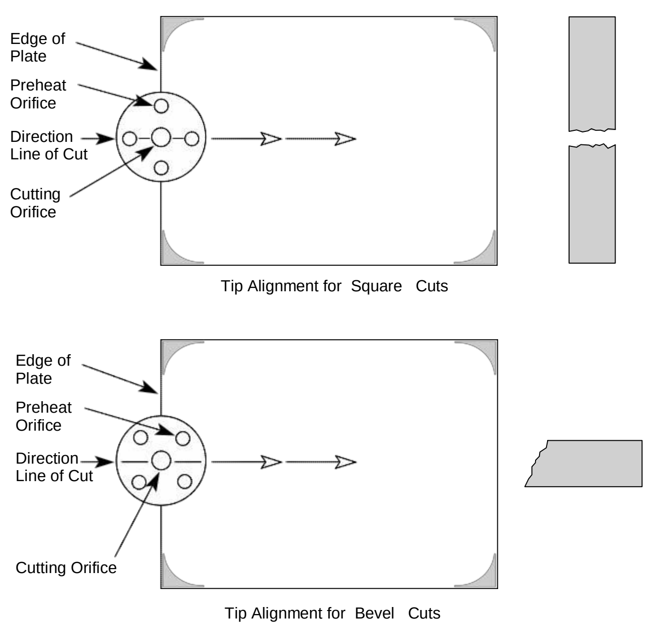


Figure 18.6

With goggles and gloves on, the blowpipe can now be lighted and the preheat flames adjusted to neutral (not more than 6mm (1/4") long) with the cutting oxygen valve open. Then close the cutting oxygen valve.

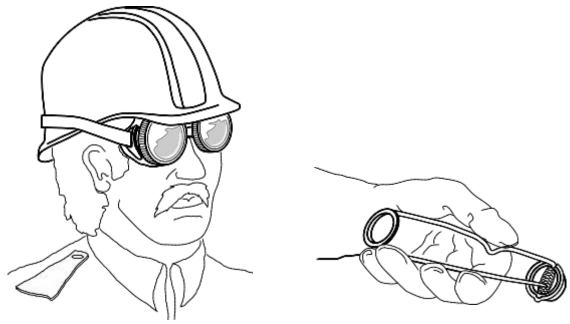


Figure 18.7

The next step is to get the body into a comfortable position, which will permit the operator to look down into the cut while keeping body sway at a minimum, which helps to produce a smooth uniform cut.

To start the cut, hold the nozzle perpendicular to the surface of the work with the inner cones about 2mm (1/16") above the material to be cut. Hold the blowpipe steady at this point until the metal reaches a bright red, then slowly but completely depress the cutting oxygen lever until a shower of sparks from the lower side of the work indicates the cutting action has penetrated entirely through the work.

The nozzle should then be moved steadily at a speed just sufficient to produce a slight amount of drag or lag from the underside of the work. Maintain the height of the preheat flames at 2 mm (1/16") above the work.

Beveling

One of the most important functions of flame cutting is to prepare metal for welding by beveling the edges to form a "V" groove to receive the weld deposit. To do this form of cutting, the nozzle is held in position to produce the required angle of cut, first making sure that the preheat holes are correctly aligned for bevel cutting, as described previously.

When cutting, great care must be exercised to keep the blowpipe steady and at a correct and uniform distance from the work so that a smooth cut of the required dimensions will be produced.

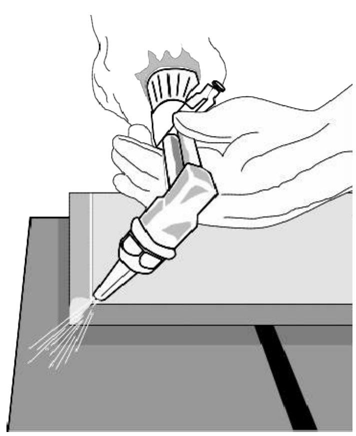


Figure 18.8

Correctly made cut

This is a correctly made cut in a 1” (25mm) steel plate. The edge is square and the draglines are essentially vertical and not too pronounced.

Common cuttingproblems

Preheat flames were too small for this cut resulting in a slow cutting speed, causing gouging at the bottom.

Preheat flames were too long resulting in the surface metal melting and running over into the cut, the cut edge being irregular, and an excessive amount of adhering slag.

Oxygen pressure was too low resulting in the surface metal melting and running over into the cut, because the cutting speed was too slow.

Oxygen pressure was too high and the nozzle size too small resulting in control of the cut being lost.

Cutting speed was too slow resulting in irregularities of the dragline and being emphasized.

Cutting speed was too fast resulting in a pronounced break in the dragline and an irregular cut edge.

Blowpipe travel was unsteady resulting in a wavy and irregular cut edge.

Cut was lost and not carefully restarted resulting in gouges at the restarting point.

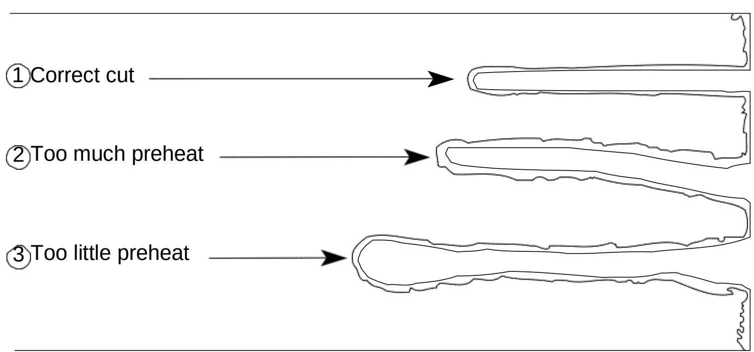


Figure 18.9

The top views of one good and two bad cuts are shown in the illustration above. The defects in these cuts are:

1) Correct procedure was used in making this cut.
2) Too much preheat was used and the nozzle was held too close to the plate resulting in the surface metal melting and running over into the cut.
3) Too little preheat was used and the flames were held too far from the plate resulting in too wide a cut on the surface.

Cutting speed

Due to the varying abilities of individual welders and equipment capabilities, specific figures for cutting speed cannot be given, except as ranges, ex. 370mm (15”) to 580mm (23”) per minute for a 13mm (1/2”) steel plate. However, when examining the surface of a completed cut, in samples of a similar thickness will indicate when compared to the above illustrations if the speed and adjustments are correct.

Cutting holes

Piercing a small hole

Hold the inner cones of the preheat flames steady 6mm (1/4”) from the plate and when the plate reaches a bright red, slowly press the cutting lever. As the cutting action starts, slowly raise the flames away from the plate to about 13mm (1/2”) so that the oxide or slag that is formed will not foul the cutting nozzle. At the same time, move the nozzle slightly to one side to create somewhat of a spiral motion. When the cutting action has pierced the metal, lower the preheat flames to a cutting distance of 2mm (1/16”) and enlarge the pierced hole to the required dimensions and shape.

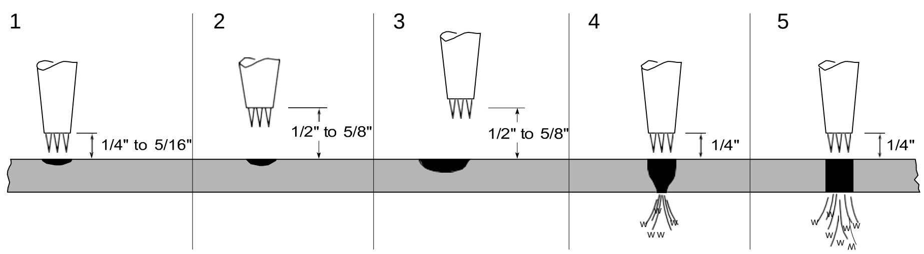


Figure 18.10 – Sequencefor piercing small hole

Cutting large holes

First chalk or center punch the dimensions of the hole, then pierce the metal in the scrap center portion of the hole. Move the cut to the outline of the hole to be completed. When cutting circles, or large holes, use your arm, or your hand, or a block, as the inside end of the radius and form a pivot point for the blowpipe to swing on.

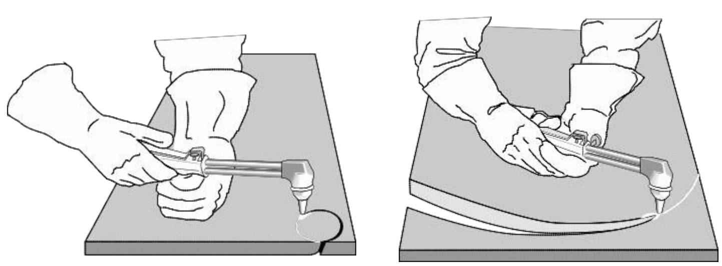


Figure 18.11

Flame gouging

Flame gouging provides a means for quick and accurate removal of surface metal. It may be used to remove metal from the back side of a weld in preparation for making a back pass or the removal of weld defects. It is also used for the removal of base metal defects in preparation for repair welding of defects such as cracked or defective weld deposits *(ex.:* in hold down housings on spring frogs*)*. It is much the same process as for flame cutting, except that a relatively large volume of cutting oxygen is delivered at low velocity.

To operate the gouging nozzle, preheat the metal as in preparation for cutting but with the nozzle held at about a 20° angle. As the metal reaches a bright red, slowly press the cutting lever and, as the gouging action starts, decrease the angle of the nozzle to about 5° from horizontal. This latter configuration may be altered in accordance with the depth of the required groove. If too great an angle is maintained, it may be found that the slag formed from the gouging action may flow back into the completed groove. For best results, the nozzle should follow the gouging action by about 6mm (1/4”) to 13mm (1/2”) measured from the tips of the inner cones of the flames to the metal being burned.

Procedure for flame gouging

A typical oxygen gouging operation: A low velocity cutting jet is used to enable better control of the gouge width and depth.

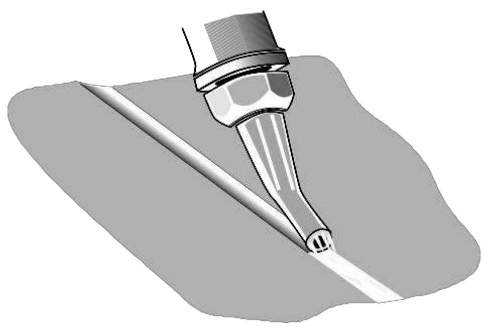
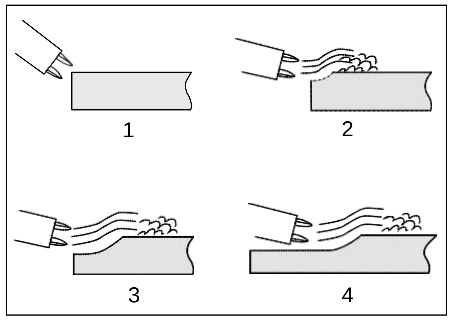
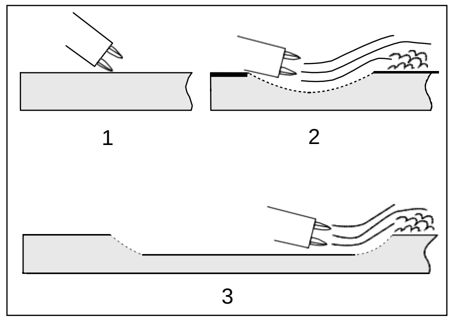


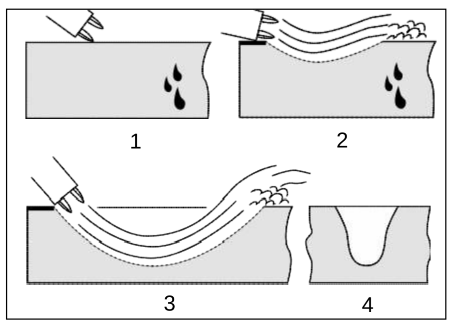
Figure 18.12



The four steps in starting a groove at the edge of a plate.



When starting a groove on the surface, draw the nozzle back a bit as you depress the cutting lever.



Spot gouging to remove a defect - the trick is to increase the angle without advancing the nozzle. A profile of a deep groove is shown at step 4.

Breakdown of flame cutting

Flame cutting is really nothing more than the burning of metal. The temperature of the metal is raised to a degree at which it will burn in an atmosphere of pure oxygen (not air) and then pure oxygen is introduced.

Oxygen on heated metal:

1. Mixes with the metal.
2. Forms oxide, a process known as oxidation.

The process involves:

1. Concentrated heat.
2. Formation of oxide.
3. Flowing of the oxide/blowing away of the oxidized metal or slag.
4. Exposure of the metal under the oxide to the oxidizing action.

Points to remember

Flame cutting produces:

1. Extremely rapid expansion of the metal along the cut.
2. Extremely rapid contraction due to the air and metal quench.
3. Some distortion of the metal along the cut edge.

The mechanical properties of the base metal must therefore be considered.

Mild steel, under 0.20% carbon presents little or no difficulty, because it is not air harden able.

Appendix A: Personal Protective Equipment

Required Safety equipment for the use of the cutting torch:

1. All normal personal protective equipment including but not limited to: (hard hats, safety glasses, vest and safety boots)
2. Clothing must not be torn, tattered, frayed, excessively oily, and/or greasy, not of synthetic material and no cuffs on pants or sleeves.
3. Safety face shield, over your safety glasses or goggles.
4. The proper lens shade for the size and type of material being cut. (# 5 lens is recommended for cutting steel from 1/8'' to 6")
5. Welder's gauntlet gloves. Long cuffed, recommended leather.
6. Long sleeves, or recommended welders sleeves / jacket of (kevlar or leather)
7. Leather leggings, or chaps to completely cover legs below knee, or recommended welders pants / bibs (kevlar or leather)
8. Hearing protection, (plugs or muffs)
9. Respirator may be required depending on the material or work area. (Confined space, lead paint, galvanized, etc)
10. Additional protective equipment or devices may be required for work out of normal position. (Bridges, Roadway Equipment etc., vertical/overhead).
11. Fire protection of the proper type readily available. (Out and ready to use). Recommended to have a fire watch. Provide spark shields or guards when material is being cut. (# 5 lens is recommended for cutting steel from 1/8'' to 6")

Rail Cutting Procedures:

1. Be aware of your surroundings, check your work area:
2. Fire potential, flammable material, (wet down area if needed, use shields or guards)
3. Wind direction, (which way will the sparks be going)
4. Body position, (keep yourself and coworkers clear of flying sparks and/or slag)
5. Make sure that tie crib pockets have been cleaned deep enough for slag or molten metal. Cover frozen ballast with a steel pan, plate or shovel.
6. Never straddle the rail, while destressing or relieving pressure. (Secure the rail if needed)
7. Never stand in front or behind bolts while cutting.
8. While destressing rail make sure to always cut from the top downward. (The "H" cut is the preferred method to destress rail under tension).
9. After cutting has been completed, check your work area for smoldering material or possible fire potential. (Wet down area if needed, or assign a fire watch to area with adequate water supply).
10. Make sure work area is clean and free of all hazards.

Personal Protective Equipment (PPE) Charts

The following pages contain two craft-specific PPE charts for Engineering that outline requirements for protective equipment. The PPE charts are designed to work in conjunction with GO Transit Track Worker Safety Instructions, section 3 Personal Protective Equipment(PPE) and Clothing, Table 1 General PPE Requirements.

GO Transit General PPE Requirements: Requirements for hearing protection, protective hand-wear, eye and face protection, shin guards, respiratory protection, reflectorized vest, disposable overalls, rubberized aprons, and welding apparel (refer to Welding Shade Chart).

Welding Shade Chart: Outlines welding shade requirements for specific welding operations.

NOTES: Face-shields are more restrictive than goggles and can be substituted for goggles. Basic requirement always includes safety glass with side-shields unless goggles are worn. Shin guards are more restrictive than leggings and can be substituted for leggings.

GO TransitGeneral PPE Requirements **R =** Required equipment **X =** May be required based on task and materials √ **=** Recommended additional equipment	Hearing Protection	Gloves	Rubber Gloves	Goggles	Face-shield	Shin Guards	Respiratory Protection Contact Safety Department
Abrasive grinding (frog grinding portable)	**R**	**R**			**R**	**R**	**X**
Abrasive grinding or cutting (stationary: bench grinder, chop saw, etc.)	**R**	**X**			**R**		**X**
Adzing machine	**R**	**R**			**R**	**R**	**X**
Banding materials		**R**			√		
Batteries: handling or servicing		**R**	**X**	**R**			
Blowing/cleaning with compressed air, steam, or water	**R**	**R**	**X**	**R**	**X**		**X**
Boring, reaming, or drilling	**R**	**X**			**X**		
Boutet or thermite welding	**R**	**R**			**R**	**R**	**X**
Breaking frozen material (ice, ground, gravel, cinders, ballast, etc.) with hand tools		**R**			**R**		
Breaking or cutting concrete, stone, or asphalt	**R**	**R**			**R**		**X**
Buffing/polishing with wire wheel	**R**	**X**			**R**		
Cadwell bonding	**R**	**R**					
Carbon-arc cutting and gouging	**R**	**R**					
Chain saw	**R**	**R**			**R**		
Chemicals, refrigerants, or fuels: handling		**R**	**X**				**X**
Chipping or cutting	**R**	**R**		**R**			

NOTES: Face-shields are more restrictive than goggles and can be substituted for goggles. Basic requirement always includes safety glass with side-shields unless goggles are worn. Shin guards are more restrictive than leggings and can be substituted for leggings.

		Welding Protective Equipment See Welding Shade Chart						Remarks/Special Requirements
Reflectorized Vest	Disposable Overalls	Rubberized Apron	Welder's Jacket or Sleeves	Welder's Leathers	Spats/Leggings	WeldingGlasses	Welding Helmet	
								Steel instep protection.
		X						Remove watch if not covered by gloves.
		X						
						6-8		
					R			
							R	
								Chain saw leggings/chaps.
	X	X						

NOTES: Face-shields are more restrictive than goggles and can be substituted for goggles. Basic requirement always includes safety glass with side-shields unless goggles are worn. Shin guards are more restrictive than leggings and can be substituted for leggings.

GO TransitGeneral PPE Requirements **R =** Required equipment **X =** May be required based on task and materials √ **=** Recommended additional equipment	Hearing Protection	Gloves	Rubber Gloves	Goggles	Face-shield	Shin Guards	Respiratory Protection Contact Safety Department
Chop saw	R	R			R		
Cleaning agents: spraying/general use		X	X	X	X		X
Climbing equipment		R					
Climbing poles and rail/work equipment		R					
Cut-off disks, saws, or other tools with carbide bits	R	R			R		
Cutting rivets, bolts, or cotter keys; splitting nuts; etc. (mechanically)	R	R			R		
Cutting rivets, bolts, or cotter keys; splitting nuts; etc. (mechanically with torch)	R	R		R			
Dusty conditions							X
Electrical hazard		X					
Electrical welding	R	R					X
Gas welding, cutting, or heating	X	R					X
Hammer-punch	R	R					
Hand tools	X	X					
Intermodal facility: outside of offices	R	X					
Lifting and carrying		X					
Machining steel, iron, or other metals	R	X			X		
MIG/TIG welding	R	R					X

NOTES: Face-shields are more restrictive than goggles and can be substituted for goggles. Basic requirement always includes safety glass with side-shields unless goggles are worn. Shin guards are more restrictive than leggings and can be substituted for leggings.

		Welding Protective Equipment See Welding Shade Chart						
Reflectorized Vest	Disposable Overalls	Rubberized Apron	Welder's Jacket or Sleeves	Welder's Leathers	Spats/Leggings	WeldingGlasses	Welding Helmet	Remarks/Special Requirements
		X						
					X			
						6-8		
	X							
			√	√			**R**	
			√	√		**6-8**		
			√	√			**R**	

NOTES: Face-shields are more restrictive than goggles and can be substituted for goggles. Basic requirement always includes safety glass with side-shields unless goggles are worn. Shin guards are more restrictive than leggings and can be substituted for leggings.

GO TransitGeneral PPE Requirements **R =** Required equipment **X =** May be required based on task and materials √ **=** Recommended additional equipment	Hearing Protection	Gloves	Rubber Gloves	Goggles	Face-shield	Shin Guards	Respiratory Protection Contact Safety Department
Mule: operation of car mover	R	R					
Painting/spray painting	X	X					X
Outdoor activities							
Pneumatic tools	R	R					
Powder-actuated tools	R	R		R			
Rail drill	R	R					
Rail grinder	R	R			R	R	
Rail saw	R	R			R		
Sand blasting (abrasive blasting)	R	R					R
Scaling, scraping, or removing welding flux	X	R			X		X
Steam cleaning	R	R	R		R		X
Striking or striking with hardened tools/fastenings	X	R					
Washing locomotives	R	R	X				
Woodworking machines	R	R			X		

NOTES: Face-shields are more restrictive than goggles and can be substituted for goggles. Basic requirement always includes safety glass with side-shields unless goggles are worn. Shin guards are more restrictive than leggings and can be substituted for leggings.

		Welding Protective Equipment See Welding Shade Chart						
Reflectorized Vest	Disposable Overalls	Rubberized Apron	Welder's Jacket or Sleeves	Welder's Leathers	Spats/Leggings	WeldingGlasses	Welding Helmet	Remarks/Special Requirements
	X							
X								
					R			
	X							Sand blast hood.
		X						
		X						

Welding Shade Chart **R =** Required equipment	Lens selection guide for filter shades that must be used when welding and cutting								
	Shade Number								
	2	3 or 4	4 or 5	5 or 6	6 or 8	10	11	12	14
Carbon-arc cutting & gouging						**R**	**R**	**R**	**R**
Carbon-arc welding									**R**
Gas shielded-arc welding (ferrous): 1/16”, 3/32”, 1/8”, 5/32” electrodes								**R**	
Gas shielded-arc welding(non-ferrous): 1/16”, 3/32”, 1/8”, 5/32” electrodes							**R**		
Gas welding: up to 1/8”			**R**						
Gas welding: 1/8” to 1/2”				**R**					
Gas welding: 1/2” and over					**R**				
MIG welding							**R**	**R**	**R**
Oxygen heating and cutting: up to 1”		**R**							
Oxygen heating and cutting: 1” to 6”			**R**						
Oxygen heating and cutting: 6” and over				**R**					
Plasma-arc cutting: less than 300 amps						**R**			
Plasma-arc cutting: 300-400amps								**R**	
Plasma-arc cutting: greater than 400 amps									**R**
Shielded metal-arc welding: 1/16”, 3/32”, 1/8”, 5/32” electrodes						**R**			
Shielded metal-arc welding: 3/16”, 7/32”, 1/4” electrodes								**R**	
Shielded metal-arc welding: 5/16”, 3/8” electrodes									**R**
Soldering	**R**								
TIG welding: less than50 amps						**R**			
TIG welding 50-150 amps								**R**	
Torch brazing		**R**							

Appendix B: SpecificTurnoutMaintenance Procedures

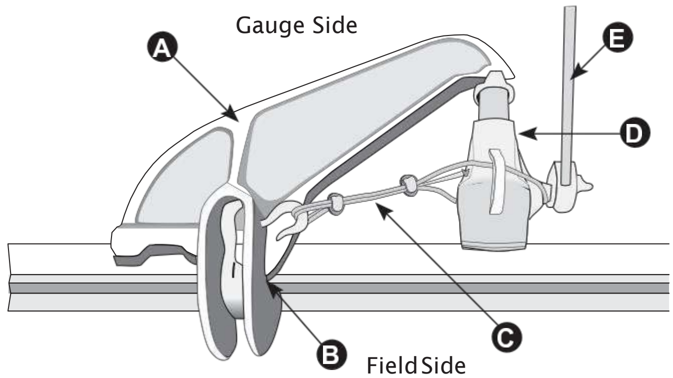
1.0 BENDING A STOCK

2.0 INSPECTING RAIL BRACES

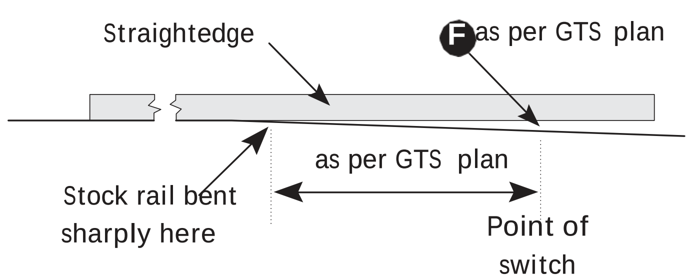
3.0 INSPECTING HEEL BLOCK ASSEMBLIES

1.0 Bending a Stock Rail

Your foreman will select an appropriate rail and hydraulic rail bender, and then make all necessary measurements as to where the bend is to be made.



1. Place the hook of the rail bender (A) over the rail head so that the bender and jack are on the gauge side of the rail.
2. Line up the jack-side edge of the hook with the bend mark (B) on the rail.
3. Place blocking under the bender to hold it in a horizontal position.
4. Attach a safety cable (C) from the jack to the bender.
5. Install bender jack (D), making sure the foot of the jack is seated properly on the gauge side of the rail head at a 90° angle to the rail.
6. Hold bender in a horizontal position as pressure is applied with the jack.
7. Operate bender with jack bar (E) until estimated amount of bend is achieved.
   - You must over bend the rail **slightly**, since it will spring back a bit once the jack is removed.
   - Do not over bend the rail too much; bending a rail back accurately is very difficult.
8. Take note of the reference mark on the piston of the jack.
9. After about 10 minutes, remove the bender and jack.



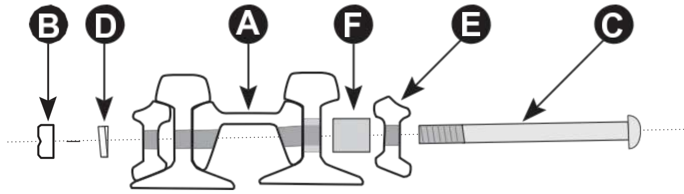
10. Measure the amount of bend at the point of switch. (F)
    - The bend should equal the measurement specified for that particular turnout in its GTS plan.
11. If the bend meets the specification as indicated on the GTS plan for that turnout, the bending process is completed.
    - Otherwise repeat the steps of the procedure and bend past the reference mark previously noted on the jack piston.

Specific Turnout Maintenance Procedures

2.0 Inspecting Rail Braces

1. Loosen the bracebolts.
2. Remove brace bolts, spring washers and double washers as a unit.
3. Tap brace to loosen.
4. Inspect brace for cracks or other defects.
5. Clean debris from double nut.
6. Reinstall brace.
7. Tighten brace by tapping just until the gap closes between the rail base and the switch plate on the gauge side of the stock rail.
8. Tighten brace bolts until the spring washer(s) compress.

3.0 Inspecting a Heel Block Assembly



1. Pull the spikes on (A) the gauge side of the heel joint.
2. Loosen all nuts (B) on heel casting bolts. (C)
3. Tap bolts into heel assembly, then remove nuts and spring washers (D) from bolts.
4. Remove bolts on gauge side of heel assembly.
5. Remove bent bar. (E) (F)
6. Inspect pipe thimble for damage and replace if necessary.
7. Plug spike holes.
8. Re-install the bent splice bar on the gauge side.
9. Install the bolts, replacing any that are damaged.
10. Tighten bolts on the frog side of the assembly starting with the centre bolt.
11. Then tighten bolts on the point side, again, starting with the centre bolt so that the bolt with the pipe thimble is tightened last.
12. Re-spike on gauge side.
13. Re-install the bent splice bar on the gauge side.
14. Install the bolts, replacing any that are damaged.
15. Tighten bolts on the frog side of the assembly starting with the centre bolt.
16. Then tighten bolts on the point side, again, starting with the centre bolt so that the bolt with the pipe thimble is tightened last.
17. Re-spike heel joint assembly.

Tightening Sequence