Track and Structures

Track Maintenance Training

Course - Rail Technology

Rail Installation & Maintenance

Metropolitan Atlanta Rapid Transit Authority
Infrastructure Training

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Introduction

Track Structure training provides a review of MARTA maintenance and railroad standards. At the end of this module, students will be able to describe basic Rail Installation and Maintenance used at MARTA and demonstrate how to correctly use this knowledge in rail maintenance.

Requirements

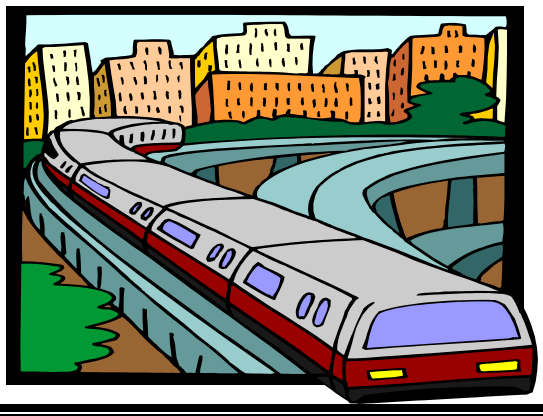
Test scores must be 80% or higher on all written evaluations. Only one retest will be allowed on any written evaluation without additional training. All MARTA Track and Structures personnel must demonstrate knowledge of MARTA Rail Laying and Maintenance procedures.

Each student will be asked to complete a class/instructor evaluation at the end of the class.

Learning Objectives

Class Objective

Demonstrate the ability to correctly describe all standard rail laying procedures in accordance with the MARTA and railroad standards.



Section Objectives

Describe rail shape, size, rail brands and rail stamping and demonstrate this ability on a section of rail of the instructors choosing.

Describe the differences between control cooled and heat treated rail and where on the system are these types of rail used and why.

Describe the difference between tinsel and compressive forces in CWR and how each effect the track structure.

Describe how CWR is replaced and how that rail is adjusted correctly and why it is adjusted.

Describe the process used to de-stress CWR.

Describe the effects of temperature changes on CWR.

Describe the differences between buckled track an a pull-a-part and what can cause each.

Describe curved warn rail, where it will be found, what causes it and how to prevent it.

Describe transposing rail, also describe the parameters used to determine if the rail is suited for transposing.

Describe truck hunting and where it can be found. Also describe the damage it can cause to the track structure.

Describe what can be done to prolong rail life.

Rail and Rail Installation

A. Rails

It all starts with the loads being transferred from the wheels to the rails.

So let's first consider the rails.

- The type of rail, which is in general use, is known as **tee rail**, except for a limited amount of rail in track built within paved streets.
- The principal parts of the tee rail are known as the **head**, **the web** and **the base**.
- When rail is placed in track, the side of the rail, which faces the center of the track, is known as **the gauge side.**
- The side of the rail towards the outside of the track is known as **the field side**.

Rail, Shape and Size

Tee rail comes in many sizes and with some minor variations in shape.

Rail is usually identified according to its weight per yard and by the shape of its cross section.

Size

For example, 115 RE rail means that a piece of this rail 3-feet in length weigh 115-pounds and that its shape is according to the design recommended by the American Railway Engineering Association. (AREA)

Most railroads have a number of differently sized rails in track. This is because the trend over many years has been for the size of rails to increase to meet the demands of cars and locomotives of ever increasing capacity.

Usually, the older and lighter rail sections will be found in yard and industrial tracks and in branch lines with lesser density of traffic.

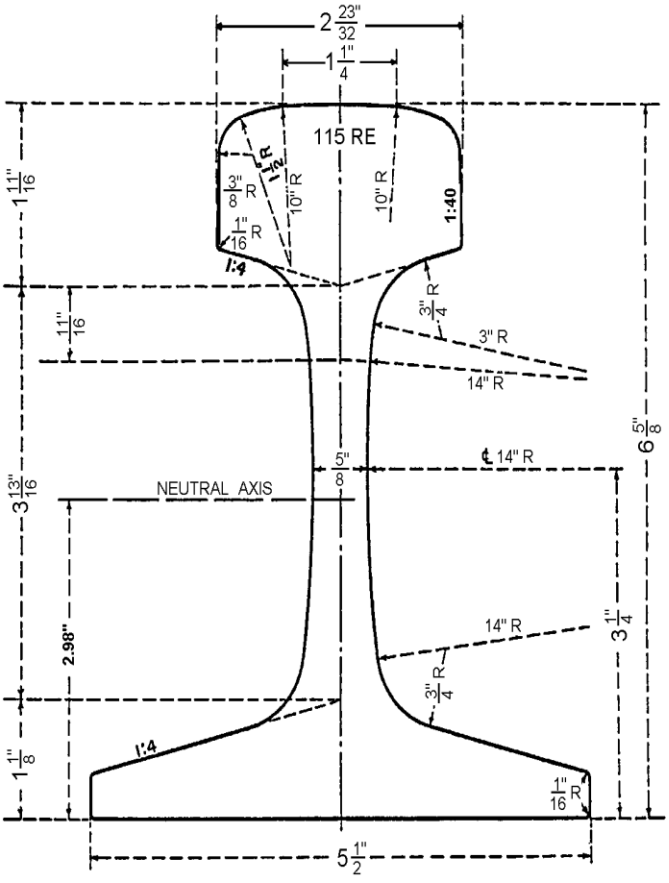
Rails

Here at MARTA we have only one size of rail. That is 115-pound rail. This rail is standard throughout the system.

This drawing shows the dimensions of the rail.

All rails have certain markings on each side of the web that gives a good deal of information about the rail.

At times it may be necessary to do a good bit of scraping or cleaning with a wire brush to read these marks.



On one side, the characters will be branded with raised letters and figures. An example would be as follows:

Rail Brands

The rail web is branded at least every 16 feet, and the branding will consist of the following information:

- Weight per every 3 feet of rail: two- or three-digit number
- Section: two-letter code
- Type of process used for hydrogen elimination: two-letter code
- Manufacturer: spelled out, letter code, or symbol
- Year rolled: four-digit number
- Month rolled: lines or roman numerals

Example:	**115**	**RE**	**HH**	**VT**	**Mittal**	**1974**	**l l l l l l l**
	Rail Weight	Section	Type of Steel	Method of Hydrogen Elimination	Manufacturer	Year Rolled	Month Rolled

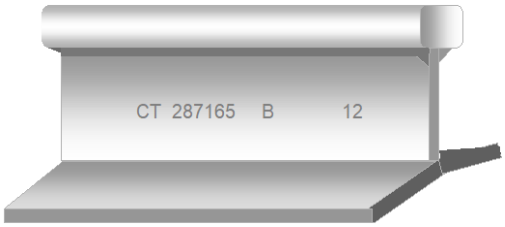
115 RE CC Name of Mill 1974 lllllll

- This means that the rail is of the 115-pound RE section.
- CC stands for control cooled.
- The name of the mill at which the rail was manufactured will be identified. Such as Workington, Tennessee or Bethlehem Steel.

The year and the month (seven vertical strokes indicating July) in which the rail was manufactured is shown.

Rail, Stamped

The web of each rail is “hot stamped” at least every 16 feet on the opposite side as the branding and should not be within 2-foot proximity of a rail end. The data will contain the following information:



- Heat Number
- Rail Position Letter
- Ingot or Strand/Bloom Number
- Method of Hydrogen Elimination (Optional)

Note: Ingots are numbered by letters that succeed each other starting with “A,” designating their position in the cast. Strand/bloom numbers may be joined or separately coded at the manufacturer’s preference.

Example:	**CH**	**36548**	**B**	**27**
	Grade Of Rail	Heat Number	Rail Position	Strand & Bloom Number

On the other side the characters are indented. Following is an example:

- CH means that the rail is heat- treated. (HT)
- The following numbers indicate the heat number from which the ingot is poured.
- The letter B indicates that it is the second rail from the top of the ingot.
- This is followed by the strand & bloom number.

Rail Manufacturing Process

The manufacturing process of steel requires huge quantities of raw materials and many processes. Steel is essentially a combination of iron and carbon. These products, along with other alloys, determine the metallurgical characteristics of the finished steel.

- For example, to manufacture 1 ton of steel, it can take 1⅓ tons of iron ore; ⅔ ton of coal; 1/5 ton of limestone; ¼ ton of iron and/or steel scrap; 165 tons of water; and 8 tons of air. Other alloys are added to alter the metallurgical structure of the steel.

Rail manufacturing can be grouped into four stages. They are:

(1) The production of molten steel from the necessary raw materials;
(2) The casting of the liquid to form ingots or continuously cast blooms;
(3) The rolling process to form cross sections of rail; and
(4) Finishing, which consists of cooling, straightening, cutting to the desired length, and final inspection?

Current steel for rail is produced by the basic oxygen process or by the electric arc furnace process; in effect, heat produced by gas or electricity. Both of these processes produce a molten steel material of high quality that is ready to be rolled into rails. While in the liquid, it is then poured into molded ingots.

After the ingots have cooled and solidified, they are stripped from the molds and sent to a soaking pit. In the soaking pit, they are reheated to a rolling temperature of approximately 2350 °F.

- Once this temperature is reached, they are moved to the rolling or blooming mill where they are rolled into their final form. The rail usually reaches a temperature below 1900 °F during completion of this process.

When the rolling is completed, each of the rails is moved to the cooling bed and cooled to about 1000 °F.

- The purpose of control cooling is to reduce the hydrogen content and improve the hardness of the rail.

After the rails are removed from the control-cooling bed, they are passed through a roller and straightened vertically and laterally.

- Once the rail is straightened, it must pass the inspection process prior to shipment.

Steelmaking Processes of Hydrogen Elimination

The steelmaking process will identify the method that hydrogen was removed from rail steel while in the molten state or in ingot, bloom, strand, or rail section form. The most common method in North American steel is controlled cooling. The methods used are identified by the following:

- CC – Control Cooled
- BC – Bloom Cooled
- VT – Vacuum Treated
- HH – Head Hardened
- OH – Open Hearth Method

Gases absorbed by the liquid steel during the heat process can cause shatter cracks, voids, inclusions, and other harmful phenomena in the steel after it has solidified.

Hydrogen has been recognized for some time to be the predominant cause for shatter cracks and other inclusions during the manufacturing process.

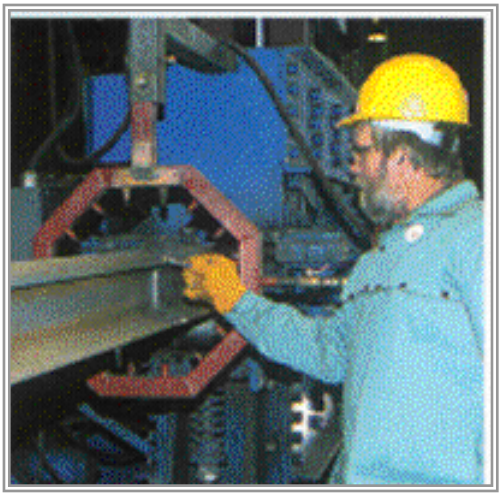
- By using one of the cooling processes above, the rail manufacturers have had significant success in removing hydrogen from rail.

Brinell Head Hardening Process

Many rail manufacturers have developed a railhead hardening process wherein the railhead is hardened to fine pearlitic structure, while increasing the hardness up to 360 BHN.

This hardness is attained at the surface of the railhead and gradually decreases to normal rail hardness at approximately 40 mm (1.6 inches or 1-3/5 inches) below the rail top.

The process involves induction heating of the rails followed by sequential compressed air cooling. This results in increasing the service life of the rails.



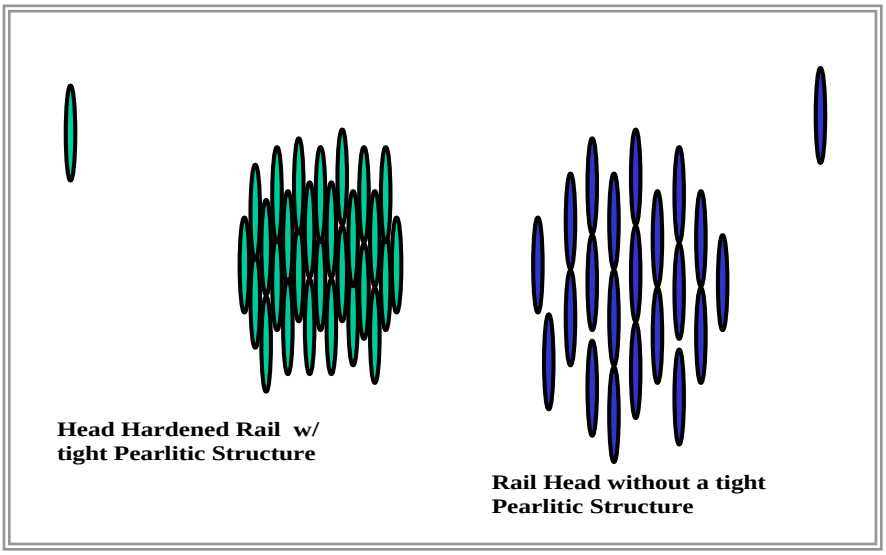
A fine pearlitic structure of the railhead increases the wear resistance and prolongs the life of the rail.
This type of rail is used in areas where there is a higher degree of rail wear.

Such areas at MARTA are in the body of curves, switches and turnouts, and also in station platforms.

- These areas are prone to a greater degree of wear than is tangent track.

Surface Hardness

The Brinell hardness test shall be performed on a rail or a piece of rail at least 6 inches long cut from a rail of each heat of steel or heat-treatment lot.



A test report shall be furnished to the purchaser.

(1) The test shall be made on the side or top of the railhead after de-carbonized material has been removed to permit an accurate determination of hardness.

(2) The test shall otherwise be conducted in accordance with ASTM E 10. Standard Test Method for Brinell Hardness of Metallic Materials, using the latest version of that test.

If any hardness test results fail to meet the specifications, two additional checks shall be made on the same piece.

If both checks meet the specified hardness, the heat or heat treatment lot meets the hardness requirement.

If either of the additional checks fails, two further rails in the heat or lot shall be checked.

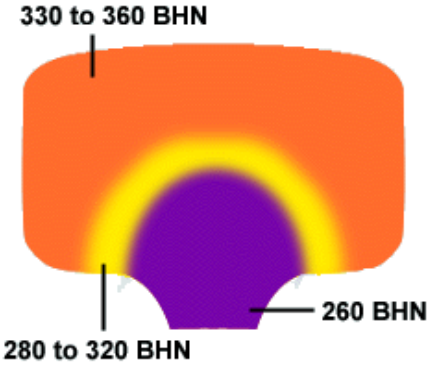
- Both of these checks must be satisfactory for the heat or lot to be accepted.
- If any one of these two checks fails, individual rails may be tested for acceptance.

If the results for heat-treated rails fails to meet the requirements the rails may be retreated at the option of the manufacturer, and such rails shall be re-tested in accordance with, the above stated procedure.

Internal Hardness of High-Strength Rail

The internal hardness of high-strength rail shall be determined on a transverse specimen cut from the head and at least 6 inches from the end of the rail.
The specimen shall be ground so that the transverse surfaces are parallel.

The hardness tests shall be conducted with either of the following methods: **Brinell (ASTM E10)1, Rockwell (ASTM E18)`, or Vickers (ASTM E92)3**.



The results shall be reported in the units of the method used.

The results shall be reported in Brinell (using ASTM E1404 for conversion) when requested by the purchaser.

The testing frequency shall be one test per heat or 10,000 feet (256 sticks) of rail whichever is the smaller amount of rail.

Tensile Properties

Rails shall be produced as specified by the purchaser within certain limits.

One longitudinal tension test specimen shall be 0.5-inch diameter and shall be tested per ASTM A370, Standard Test Methods and Definitions for Mechanical Testing of Steel Products.

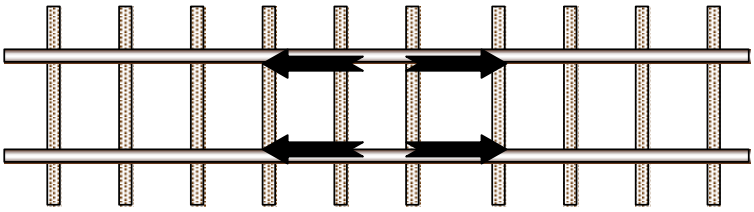
For standard rail, the test frequency shall be one test for each heat for the first one hundred heats.

One test for every fifth heat for the second hundred heats.

One test for every tenth heat thereafter for heats furnished to the same customer.

For high-strength rail, the testing frequency shall be one test per heat or 10,000 feet of rail, whichever is the smallest amount of rail.

Tinsile forces want to pull the rail apart or make it shorter



If any test specimen fails because of a malfunction of the test equipment or a flaw in the specimen, it shall be discarded and another one taken.

If a test specimen fails to meet the required tensile properties, two additional test specimens shall be cut from rails from the same lot and tested.

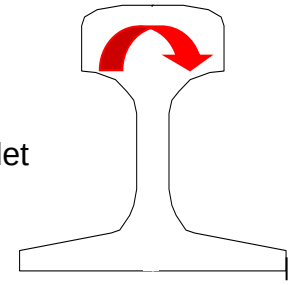
- If both meet the requirements, the lot shall be accepted.
- If one of the tests fails to meet the requirements, two additional rails from the lot shall be sampled and tested.

Both of the tests must be satisfactory for the lot to be accepted. If one of these tests is unsatisfactory, individual rails may be sampled and tested for acceptance.

If the results for heat-treated high-strength rail fail to meet the requirements, the rails represented by the test may be reheat-treated and re-tested.

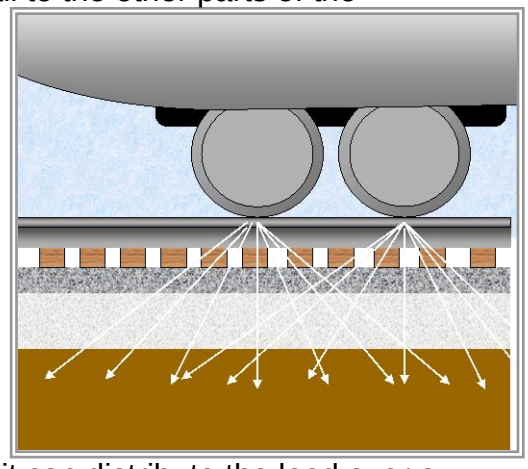
Rail Head Profile

Transverse a cross- sectional geometry of the rail head extending from one bottom fillet radius to the other bottom fillet radius of the railhead.



B. Load Transfer

The wheel loads have to be passed on from the rail to the other parts of the track structure.



The rail acts as a beam or girder in distributing the load.

Although the tie (which is directly under a wheel) receives more of the load than the adjacent ties, it does not receive the full load.

The greater the girder strength of a rail, the better it can distribute the load over a greater number of ties.

By controlling the maximum load, which a tie receives, the wear on the ties and the breakdown of the ballast support can be kept within reasonable limits.

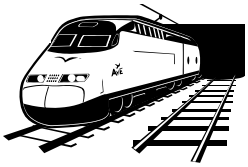
This greater girder strength is one important advantage of the heavier rail sections.

Another advantage is that a wheel load sets up lower internal stresses in heavy rail than in light rail.

- This means that heavy rail is less likely to break under traffic.

Just as the unit weight of rail has tended to become heavier over the years, so have rails tended to become longer.

C. Rail Joints

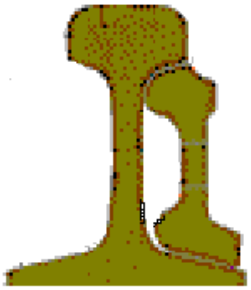


Ordinary Rail Joints,

An ordinary rail joint consists of two joint bars plus the required number of bolts, nuts and springs washers.
The two joint bars are considered to be a pair and usually have holes for six bolts.
The joint bars may be either of the toeless type or may have a toe or base angle.

They may be of either the head contact or head-free type, depending upon the portion of the area under the railhead where the bars make contact with the rails.

Here at MARTA we use the head contact type of joint bar.



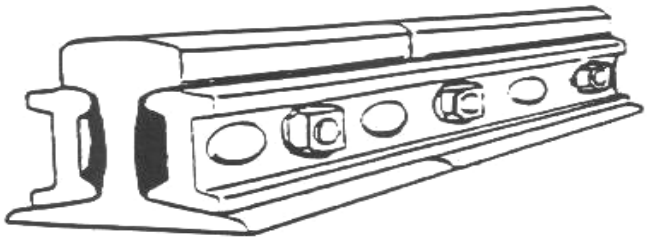
The bolts, which are used to secure the joint, are known, as **track bolts**. These bolts usually have an oval or elliptical neck under the bolt head.

The joint bars usually have alternate holes, which are oval in shape; the intermediate holes are round.

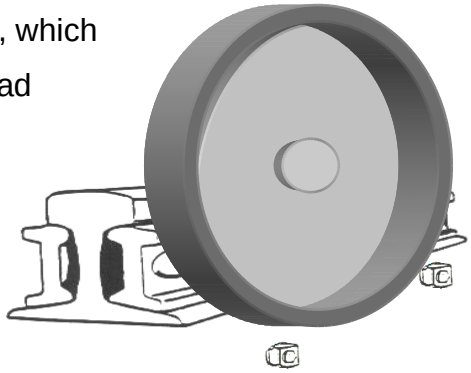
When the bars are matched up to form a joint, one on the gauge side and one on the field side of the rail, an oval hole is always opposite a round hole.

By inserting each bolt from the side with an oval hole, the oval bolt neck fits into the oval hole in the joint bar.

As long as the bolt is fully inserted, the nut can be tightened or loosened without the bolt turning. This arrangement requires that alternate bolts within a joint be inserted from opposite sides of the rail.



This pattern has potential advantage should a derailed wheel pass by the joint. Such a wheel is more likely to strike the nut, which protrudes considerably, than the rounded bolt head (which protrudes very little).



Under such conditions, it is unlikely that more than half the bolts in a joint will be broken or severely damaged.

This can be an appreciable advantage in restoring the track to service quickly, if such derailed equipment traveled several miles before being detected.

The usual practice is for track bolts to be ordered with nuts and for them to be shipped together. They are frequently accounted for as a unit. The spring washers are more commonly treated as a separate unit.

In addition to the ordinary rail joint, there are joints for special purposes.

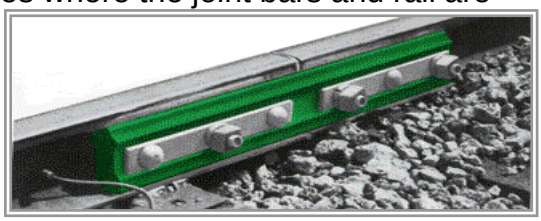
Insulated Joints

Insulated joint is electrically insulating one rail from the next.

These are used to isolate an A.T.C. signal circuits or circuits controlling automatic crossing protection for the railroads.

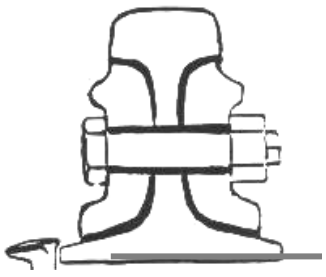
Insulated joints of more recent design have been developed to better meet the demands placed on the joint by continuous welded rail.

These joints employ adhesives on the surfaces where the joint bars and rail are in contact. The adhesives transfer much of the stress that occurs in welded rail due to temperature changes.



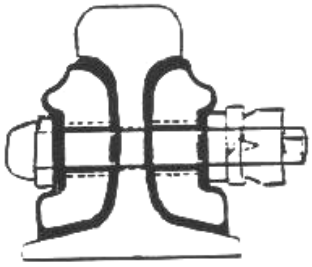
- Otherwise, these stresses would have to be carried by the track bolts.
- There are several designs of these adhesive type or glued joints that have gained widespread use.

One feature common to all of them is that they are designed so that the maximum practical area can be utilized for applying the glue material between the joint bars and the rails.



Glued Insulated Joint

TWO DIFFERENT TYPES OF INSULATED JOINTS



Portec type Insulated Joint

Compromise Joints

Another type of rail joint is the **compromise joint** (used to match heads of adjacent rails of different sections or sizes). These joints are also called **Step Joints**. Stepping from one rail size to another.

We at MARTA have only one pair of compromise joints, and they are where the MARTA track ties in with the C.S.X. Railroad behind the M.O.W. shop.

Rail Joint Maintenance

Bolts must be tightened annually when the rail gaps are closed. Tightened to the prescribed torque.

Before tightening bolts:

a. Remove the two center bolts, one at a time, and inspect for straightness.

b. If either center bolt is bent, remove the remaining bolts and inspect, do this one bolt at a time.

c. All bent bolts must be replaced.

Replace bolts and washers that are broken or missing.
Bolts threads should be oiled annually.

It is permissible to dismantle and remove joint bars without using a hydraulic rail expander, if rail temperatures are within the Bolted Rail Working Zone.

This is a working zone where rail temperatures are within the rail neutral zone. At this temperature rail will nether expand or contract.

Allowing for the rail joint to be dismantled without the rail moving.

If joint bars (another name for joint bars) must be removed when the temperature is below the Bolted Rail Working Zone, an expander or heat source should be used to close the gap that will develop when the joint bolts are removed.
Before the bolts are removed, the rail anchors or rail clips, for at least 200 feet on either side of the joint must be checked and adjusted, if necessary.

- This involves checking all the anchors to make sure that they are tight to the sides of the ties.
- Or to check the Pandrol clips to see if they are properly installed and that any loose or broken clips are replaced.

If the rail joints do not close at a rail temperature 40°F above the PRLT, the matter should be brought to the Forepersons or Managers attention.

- Where they will arrange to take any necessary action.

One method to relieve the problem would be to loosening the bolts and slackening the anchors or remove the clips, leaving every fifth clip in place to hold the rail for 200 ft. in each direction.

If the rail gaps close, the anchors must be re-positioned, clips reinstalled and the bolts tightened to the proper torque.

Rail joints other than Bonded Insulated Joints are not recommended in concrete tie territory, except as a temporary measure when repairing breaks or buckles.

The pounding caused by a rail joint on concrete ties can cause premature deterioration of the tie. Joints must be replaced by field welds as soon as

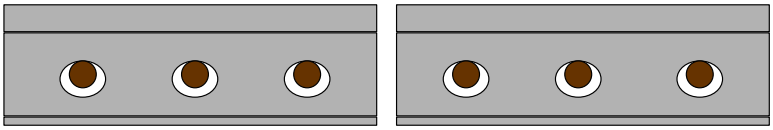
possible.

Rail Joint Gap

With the exception of the adhesive-type joints, rail joint assemblies are usually expected to permit a small amount of movement between the rail and the joint bars.

This provides for the expansion and contraction of rail in which stresses are to be relieved as the temperature changes.

Bolt holes in the rail are usually oversize in relation to the diameter of the track bolts in order to permit such movement.



a) Some railroads require that a lubricant be applied during rail-laying operations to the areas, where the rails and joint bars come in contact.
    - This reduces the frictional resistance to such movement in a joint with tight bolts.

When laying jointed rail, there is usually a small opening left between rail ends, unless the temperature is very warm when the rail is being laid. The proper way to do this will be discussed in another lesson.

It should be remembered that much of the rail traffic, which passes over a rail joint, does so while there is a small opening between the rail ends.

- Rail joints are normally designed to carry loads that the rail can carry.
- They generally do quite well if all parts are in good condition and well maintained.

Nevertheless, it is in the joint area that maintenance work is most frequently required.

- The present trend toward the use of continuous welded rail (CWR) is due to the high cost of maintaining rail joints and the fact that joints are weak spots in the track structure.

Rail Joint Deterioration

There are a number of reasons why a rail joint deteriorates.

If only one of these conditions is present, in time, some of the others will appear.

- If left uncorrected, the deterioration of the joint occurs at an ever-increasing rate.

1. The gap between the rail ends, even though small causes an appreciable amount of pounding or impact because of the heavy loads being carried.
    - In time, this impact can cause batter to appear on the head of the rail end located on the receiving rail end.
2. On tracks with a substantial amount of traffic in both directions, such as a single-track operation, this battered condition may be equally severe on both of the rail ends in a joint.
3. The vibrations caused by loads moving over a joint can also cause bolts to lose tension. If this condition is not promptly corrected, excessive movement takes place in the areas where the joint bars and rails make contact.
    - If not corrected, this will cause wear on these surfaces so that the bars become incapable of providing full support, even if the bolts are re-tightened. This wear will effect both the rail and the joint bars creating a gap between the two surfaces.
4. Any of these conditions can cause excessively high impact forces that may result in a breakdown of the joint in additional ways. (Cracked joint bars, bent or broken bolts, the detraction of the crosstie or even the breakdown of the ballast under that joint.)

D. Continuous Welded Rail

Legislation under the Federal Railway Administration has mandated the need for Continuous Welded Rail procedures. In addition, all railroads that have CWR on their property must have a training program in place to teach all employees responsible for the installation, inspection and maintenance of CWR.

The FRA must approve both the program as well as the procedures in order to comply with this new rule.

Below are some of the terms used when referencing CWR.

Adjusting/De-stressing means the procedure by which a rail's temperature is re-adjusted to the desired value. It typically consists of cutting the rail and removing rail-anchoring devices, which provides for the necessary expansion and contraction, and then re-assembling the track.

Buckling Incident means the formation of a lateral miss-alignment (sic) sufficient in magnitude to constitute a deviation from the Class 1 requirements specified. These normally occur when rail temperatures are relatively high and are caused by high longitudinal compressive forces.

Continuous Welded Rail (CWR) means rail that has been welded together into lengths exceeding 400 feet.

Desired Rail Installation Temperature Range means the rail temperature range, within a specific geographical area, at which forces in CWR should not cause a track buckle in extreme heat, or a pull-apart during extreme cold weather.

Disturbed Track means the disturbance of the roadbed or ballast section, as a result of track maintenance or any other event, which reduces the lateral and/or longitudinal resistance of the track.

Mechanical Stabilization means a type of procedure used to restore track resistance to disturbed track following certain maintenance operations. This procedure may incorporate dynamic track stabilizers or ballast consolidators, which are units of work equipment that are used as a substitute for the stabilization action provided by the passage of tonnage trains.

Rail Anchors means those devices which are attached to the rail and bear against the side of the crosstie to control longitudinal rail movement. Certain types of rail fasteners also act as rail anchors and control longitudinal rail movement by exerting a downward clamping force on the upper surface of the rail base.

Rail Temperature means the temperature of the rail, measured with a rail thermometer.

Tight/Kinky Rail means CWR, which exhibits minute alignment irregularities, which indicate that the rail is in a considerable amount of compression.

Train-induced Forces means the vertical, longitudinal, and lateral dynamic forces, which are generated during, train movement and which can contribute to the buckling potential.

Track Lateral Resistance means the resistance provided to the rail/crosstie structure against lateral displacement.

Track Longitudinal Resistance means the resistance provided by the rail anchors/rail fasteners and the ballast section to the rail/crosstie structure against longitudinal displacement.

Rail installation

Each year, hundreds of thousands of new rails are laid in track replacing rails that are no longer suitable for use.

- Rails that were removed from track because they contain defects such as those described in Lesson on Rail Defects are a small part of the total.
- Most rails are replaced because of wear.
- The most common types of wear are those that develop in joints and on curves.

Unlike defects that usually occur at random, this type of wear normally affect all consecutive rails in a stretch of some length. Replacement of rails in a continuous stretch lends itself to techniques far different from those suitable for replacement of a single rail.

New rails are usually installed in important mainline tracks.

- Many of the rails that are removed from these tracks are suitable for reuse at other locations such as yard tracks.

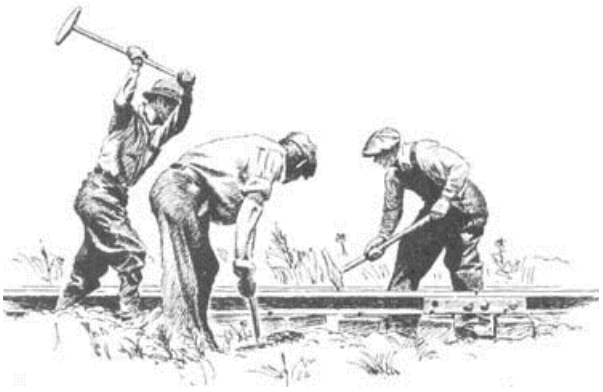
Rails that have been removed because of wear in the joint area can have the worn ends cut off.

- This process is called cropping.
- Rail that is cropped can be drilled with new bolt holes, and then re-laid as jointed rail.

Instead of drilling there, cropped rails can be welded into very long lengths to form **Continuous Welded Rail (CWR)**.

In some cases, curve worn rail is suitable for reuse in lower class tracks such as sidings and yards. The total amounts of rail both new and secondhand, which is laid in stretches to replace worn rail, is very large.

Because of the importance of this track maintenance function and the high degree of specialization frequently used, this entire lesson will be devoted to the replacement of rail in existing track as a continuous stretch.



The techniques, which are widely used in replacing rail, bear a great deal of resemblance to the assembly line methods used in many manufacturing plants.

In rail-laying operations the principal difference is that instead of the work passing by track personnel and equipment stationed at fixed locations, the personnel and equipment must continually advance over the track section being worked on.

The greatest part of the physical work is performed at the time the old rail is removed from track and replaced with either new rail or relay rail of a better quality.

- There is work that must be performed in advance of this operation and there is work that must follow it.

The efficiency with which the replacement operation is carried out and the quality of the final job depend to a large extent on the effectiveness of these other phases of the job.

The entire process of replacing a stretch of rail can be considered in four phases.

They are:

1. Planning 2. Preparation 3. Installation 4. Follow-up

Other Track Material (OTM) Requirements

In addition to determining the quantity of rail that will be required and identifying problems that may be encountered in distributing the rail, it will be necessary to determine the quantities of the various track fittings that will be required.

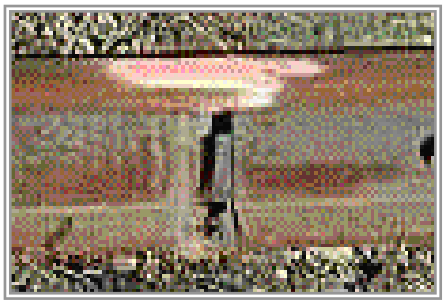
The standard track fittings to be used, usually classified as **Other Track Material** and, usually, abbreviated as **OTM**, will be largely affected by several conditions. They are:

- Will jointed rail or continuous welded rail be installed?
- Will the tie plates or pads be replaced, or will be same plates or pads be reused?
- Will fasteners, such as Pandrol clips and pads be reused or replaced.

If continuous welded rail (CWR) is to be installed, joint bars, bolts, nuts and lock washers or even an insulated joint may be required.

It is necessary to determine the procedure that will be used to connect each string of CWR.

- Conventional joints may be used
- Thermit welds.

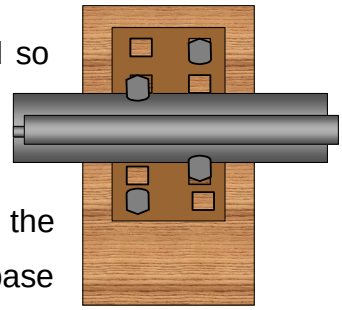


If the latter system will be used, it should be determined whether the installation will be made immediately, or if conventional joints will be needed temporarily until the thermit welds can be made.

Will there be a requirement or need for insulated joints because of the A.T.C. signal system.

The number of rail anchors required will have to be decided if within the rail yards.

Where jointed rail is used, more anchors may be required on each rail on single track than on double track because bi-directional traffic requires heavier anchoring.



- The anchor pattern to be used must be established so the total quantity needed, can be calculated.
- It must also be determined whether part or all of the rail anchors presently in the track can be reused. If the rail section is to be changed to one with a different base width, the anchors will all have to be replaced.
- Anchors which show signs of slipping should not be reused.

Where the Pandrol fastening system is used no rail anchors are needed. The Pandrol clips act as their own spikes and rail anchors, preventing the rail from moving.

Spike requirements are based on the pattern at each tie plate. At the minimum, two rail-holding spikes per plate will be used. At times, an additional gauge side rail-holding spike may be used on curves. Sometimes one or two plate holding spikes are installed.

- A decision will be needed on the anticipated reuse of spikes presently in the track.

For rail replacement on wood ties, tie plugs will be needed to insert in all holes from which spikes or lags are pulled. The type of plug required will depend upon whether a spike or a lag is being plugged.

Determining Operation Requirements

While there are great many similarities in methods used to install jointed rail and CWR, there are some substantial differences. These will have to be recognized throughout the planning process.

When the replacement rail is to be laid on the tie plates, tie pads or concrete ties presently in track, without a placement or adjustment of the plates, the process is substantially simplified.

- However, even when the tie plates or pads are not to be replaced, it is sometimes necessary to remove and reinstall the plates under one or both rails.

This is made necessary to correct gauge, alignment or improper cant of the tie plates due to plate cutting on the ties.

The ties are adzed to provide a proper seat for the tie plates while the plates are removed from the ties. The track must be inspected early in the planning stage to determine what, if any, tie plate adjustment is needed.

Anticipating Difficult Conditions

The preliminary inspection should be conducted so as to identify conditions likely to interfere with the smooth flow of work. Any locations where there is excess ballast present that would interfere with the progress of the work should be noted.

- This also applies to foreign materials such wee-zee bonds or marker coils.

Close clearances may restrict the efficiency of equipment. Hazardous locations such as bridges, aerial structures or tunnels will require special arrangements for the protection of employees and the general public along with the proper progression of the work.

The effect of rail traffic on the progress of the job should be predicted, and the work scheduled in the most practical manner and in harmony with train operations.

The situation at hi-rail access should be considered, along with the problems that rail stations, crossovers and turnouts represent.

Some of the problem situations, which will be found, can be overcome by advance preparation.

- It may be possible to eliminate the condition before installation of rail begins.

In other situations, it may be possible to handle the condition more effectively by allocating additional equipment or manpower to deal with it as the work progresses.

E. Preparation of Rail

At locations such as turnouts and insulated joints, some advance measuring and cutting of rails may be desirable in order to avoid delay while rail laying is in progress.

Short rails may be provided for this purpose to avoid waste of rail.

- If turnout stock rails prepared in shop are not provided it may be advantageous to bend and drill them in advance.

When jointed rail is being installed, it is usually desired to maintain joint stagger within specified limits.

On curves, a greater length of rail is required on the outer or hi-rail than on the inner, or low side.

- In order to maintain stagger of the joints on a curve, it is customary to insert one or more short rails on the low side.
- The total difference in rail length depends upon the degree of curvature and the length of' the curve.

Installation

The ideal situation during the course of' a rail-renewal project is for each operation to progress at a uniform rate of speed.

- No single operation should be delaying the operations, which follow, nor lagging behind those which precede it.

In practice, this is seldom attainable. There will probably be one operation that is limiting the overall productivity of the entire force. This is sometimes referred to as a **pace operation**

If the addition of another machine or more personnel to that operation significantly increases productivity, such action may he justified.
If some other operation becomes the pace operation with very little change in productivity, the additional force or equipment may not be justified.

There are other ways the best-planned jobs can encounter delays.

(a) A key machine operator may report off sick.
(b) A machine may break down.
(c) Rail traffic requirements may reduce anticipated track usage time.
(d) A sudden rainstorm or other bad weather may slow operations when rail is torn out.

There are numerous items that require frequent checking to assure the quality of the finished job.

One of these is the gauge of the track.

(a) Rail fasteners must be checked to be sure that no part of a fastener shoulder is under the base of the rail.
(b) Field side shoulders on the fasteners should be snug against the edge of the rail base and square to the rail.
(c) All specified clips should be installed and fully driven but not over driven.

All joints should be inspected. Bolt holes must be drilled as required and bolts inserted in the proper number.

No rail can be torch cut or have a torch cut bolt hole on any MARTA track.

Any mismatched rail ends must be corrected by welding or grinding.

Bolt tension should be periodically checked.

It is of utmost importance to get the proper thermal adjustment of the rail as it is installed.

When installing CWR, it is the usual practice to make a permanent record of the temperature where each length of rail was anchored.

- These temperatures are to be rail temperatures, not air temperatures.

This is found by placing a rail thermometer on top of the rail base, not in direct sunlight, for several minutes.

- If the temperature is not within the specified range, the clips will have to be removed at a later date when the rail temperature is within this range and the rail expansion readjusted.

Many crews installing CWR have rail-heating equipment and a few have rail-cooling equipment that brings the rail within the specified range before it is anchored.

- Constant use of the rail thermometer is necessary to monitor this operation.

The rail crew personnel must know the company's standards for the location and stagger of standard joints, insulated joints and both shop and field welds to see that they are installed accordingly.

- When jointed rail is being installed, the track personnel must see that the joint stagger is maintained within specified limits.

Use the following tables for joint and weld stager.

Same Rail Measurements

	Bolted Joint	Bonded Joint	Field Weld	Shop Weld
Bolted Joint	14’ 0“	14’ 0“	14’ 0“	14’ 0“
Bonded Joint	14’ 0“	14’ 0“	14’ 0“	36”
Field Weld	14’ 0“	14’ 0“	14’ 0“	14’ 0“
Shop Weld	36”	36”	14’ 0“	N/A

Opposite Rail Measurements

	Bolted Joint	Bonded Joint	Field Weld	Shop Weld
Bolted Joint	10’ 0“	14’ 0“	10’ 0“	AMAP*
Bonded Joint	AMAP*	AMAP*	10’ 0“	AMAP*
Field Weld	10’ 0“	10’ 0“	10’ 0“	AMAP*
Shop Weld	AMAP*	AMAP*	AMAP*	AMAP*

*As Much As Possible

Follow Up

After the rail is installed, there will be various items of work to be done before the job can be considered to be finished.

- Some of these jobs may be at least partially completed, while the installation of the rail is in progress.

When manpower and equipment availability permit, this can be accomplished by taking advantage of track usage available behind the rail-laying personnel.

F. Re-tightening Track Bolts

Track bolts frequently become loose after rail traffic has operated over the newly laid rail for a while.

- This may become noticeable after a few days or a few weeks, depending on the density of traffic.

This is first noticeable by a loss of tension in the lock washers. If the bolts are not re-tightened the nuts will work off the bolts, and the entire joint may become disassembled.

- Future tightening of the bolts may then only be needed at the relatively long intervals found in normal maintenance.

G. Track Surfacing

Track surfacing, in harmony with rail renewals, can take various forms. The extent of the need may vary with the class of track, and the condition of the track surface prior to the rail renewal.

In some rail-laying crews, a tamper is provided as part of the assigned equipment.

- This tamper could be used for conventional spot tamping or it might be used only to tighten up loose ties at locations where low joints existed in the old rail.

At other times, surfacing may be carried out after completion of the entire rail-laying operation.

- This could take the form of spot tamping or of a general raise. In any case, any ballast removed from the tie cribs should be restored to the cribs promptly, so that there is no loss of longitudinal restraint of the rails.

When general rehabilitation of the track is desired, it is customary to replace the rail first and then renew defective ties and to finish up with a general track raise.

This sequence brings the track to proper gauge before new ties are installed, so re-spiking does not weaken the new ties.

- By installing ties before raising track, uniformly compacted tie beds are retained. Indications of presence of high thermal force in track.

Surfacing

No surfacing shall be carried out unless there is sufficient ballast on hand to maintain the standard ballast section.

- Full cribs and minimum of 6 inches of ballast on tangent track and on the low shoulder of a curve and 12-inch shoulder on the high side of a curve.

The ballast section must be brought to standard at the end of each working day. (Or a slow order is applied)

Do not perform out-of-face surfacing when the rail temperature is not within the Working Zone.

Necessary spot surfacing may be carried out at temperatures lower than the Working Zone, but special attention must be taken to disturb as little ballast as possible on curves.

- Generally, slow orders are applied when surfacing on CWR at ambient temperatures greater than PRLT-5° F.

Special attention must be paid to the surface at the rail joints, insulated joints, and the transition zone at bridge approaches and between concrete and wood ties.

Special attention must be taken when out-of-face surfacing, not to line the curve in if the rail temperature is below the PRLT.

Lining

Lining may be carried out at temperatures within the Working Zone.

Major realignment of a curve toward the inside or the outside may require de-stressing.

- Calculations for Change in Force Free Temperature for a given throw:

Example: A 1000-foot, 4º curve was thrown in an average of 2 inches during a lining operation. What is the change in Force Free Temperature?

Use the formula:

$\Delta L = 6.3*T\ (L/100)/(360/D)$

$\approx TLD/5730$

Where: ΔL = change in length of the curve (inches)

L = length of curve in feet

T = the amount of throw in inches

D = degree of curve

$\Delta L = 6.3(2)(1000/100)/(360/4)$

$= 1.4$ inches

Then: $\Delta T = \Delta L/(L*\alpha)$

Where: ΔT = change in Force Free Temperature

α = Coefficient of thermal expansion of rail

$\Delta T = 1.4/(1000*12*0.0000067)$

$= 17.4^{o}$ F

The change in Force Free Temperature would be a decrease of 17.4º F. Since this is out of the PRLTR, the curve would require de-stressing.

When lining with jacks, make sure that the track is not lifted.

If the ends of the ties were dug out or voids created they must be filled as soon as the lining is completed.

When there is rail expansion or contraction look for these rail indicators,

Canting on tie plates, especially where small plates are used.

Crowding the shoulder of the tie plates on curves or riding up or out of the tie plates.

Scrape marks on the base of the rail caused by the spike or fastener contacting the running rail.

Uneven wear on the rail surface, or welds.

Longitudinal movement of switch point, to the stock rail, indicated by the point of switch at the gauge plate.

Kinky or snaky rail. Any sign of longitudinal movement of rail. (Note movement of fastener)

Indicators in Rail Joint Areas

Look for the following:

(a) Pull-a-parts.
(b) Heavily worn fishing surfaces on joint bars.
(c) Joints remain closed at low or moderate temperatures (rail in compression).
(d) Sliding joints out of adjustment.
(e) Track bolts that are, bent, worn or broken.
(f) Joints not closed at 40º F above the PRLT. (Indicates the rail is in tension).

Indicators at the rail fastenings

Rail Anchors that are:

a) Missing (indicates the rail is not being restrained).
b) Away from tie or plate.
c) Tight on one side and loose on the other side of the tie (indicates the rail is running).
d) Lifted spikes
e) Loose and shifted Pandrol Clips
f) Pandrol clips loose or missing on one side.
g) Skewed gauge rods.

Indicators at the crosstie area

Skewing of the ties. Moving and bunching from longitudinal movement.

Indicators in Track Geometry

Check for the following

(a) Misalignment (kinks).
(b) Changes in alignment (misalignment) during the day.
(c) Lateral or vertical movement when temperature is more than 20^{o} F above the PRLT.
(d) Buckles.
(e) Irregular gauge.

Ballast Section

Look for:

Churned ballast.

Displaced ballast, (gaps at end of ties, often on the inside of curves, low crib ballast).

H. Maintenance Requirements for Continuously Welded Rail

Plug Rails

The lists on the following pages cover the specifics you must consider when installing plug rails in CWR territory.
The particulars, including any applicable references, are listed for each type of rail closure.

Temporary Closures

When it is necessary to change a portion of rail, either for the removal of a rail defect or to eliminate joints, there are certain criteria that should be adhered to.

Temporary plug rails must not be less than 14 feet long with the following exceptions:

a) High rail access or Crossing Frogs
b) Turnouts (As permitted in the Standard Plans)
c) Bonded Insulated Joints
d) Emergency situations

After replacing defective rails or making temporary closures (except where welders are not available), the 2 holes closest to the rail ends are not to be drilled.

- During the winter season, six bolt holes may be required.

If the rail temperature is below the PRLT, every effort must be made to avoid adding rail.

- The temporary plug rail should be the same length or less than the rail taken out, and laid with the maximum gap allowable.

If the rail temperature is above the PRLT, the temporary plug rail should be laid tight, but again, not longer than the rail taken out.

Except in cases of emergency, trains or engines shall not be operated over mismatched rail ends of more than 1/4 inch on top or gauge side of rail.

Where the mismatch is greater than 1/8 inch, trains must operate according to the standards set by the MARTA Track Safety Standards until the rail has been ground, welded, or replaced.

Permanent Bolted Plugs

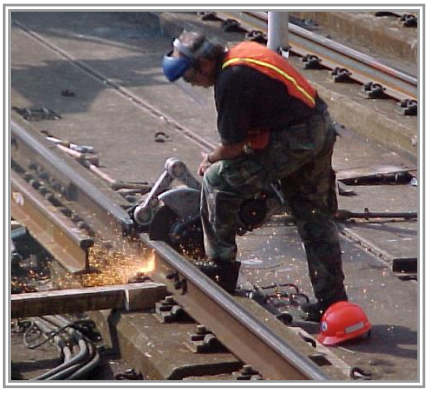
Permanent plug rails used in main tracks should be at least 14 feet long.

For Pandrol clip areas, make sure that all clips are correctly installed, replace any clips that are missing, broken or sprung.

Permanent closures must be of a compatible metallurgy with the existing rail. (Heat-treated rail to heat-treated rail)

Welded Closures

Plug rails must not be less than 14 feet long except as noted previously, or when the weld is made with a flash butt welder when the plug rail may be a minimum of 8 feet.



Plug rails may be welded when the nearest bolt hole is not less than 4 inches from the weld.

When making cuts for field welds, a gap of 7/8" to 1 inch must be cut out to compensate for each weld.

All cuts in the rail must be square and true. Rails to be welded must be cut with a saw; it is not good practice to thermite weld torch cut rails together.

Here at MARTA, we never put torch cut rail into the track.

When replacing defective rail or making temporary closures and welders are not immediately available, the 2 holes closest to the rail ends should not be drilled when joint bars applied.

Rail having cuts or holes made with welding equipment must not be used in the track.

When cutting rail for re-use, the saw cut must be at least 2 inches from any torch mark on the rail.

Relaying/Transposing

When laying CWR the rail should be laid at a temperature at or below the PRLT.

If the ambient temperature causes the rail to be laid below the PRLT, then heaters or expanders should be used to bring the rail to the desired length.

When expanders are used, remember to use the charts in the Recommended Procedures for De-stressing Rail to determine amounts to be pulled.

On completion of the day's work, rail must be fully spiked, clipped and bolted (if it is not immediately welded), and anchored.

- If the track cannot be fully anchored after a relay or transposing operation, a 10 MPH Slow Order should be applied.

The rail temperature, at which each string of CWR has been anchored, shall be painted on the web of each rail, at each end of the string on the field side.

When rail heaters, coolers, or expanders have been used to obtain the proper length of rail, the rail temperature to be marked on the rail shall be the PRLT.

Rail Replacement

This procedure has been designed for removing existing running rail on MARTA's mainline operating system tracks and replacing with new rail in kind.

This procedure has been revised to reflect procedure changes for changing rail on Aerial Structures and procedures for changing rail in Subways and Ballasted Track.

At the minimum, the following shall be taken into consideration:

1. **Safety**, to protect any personnel or equipment from injury or damage.
2. **Quality,** to ensure the rail replacement is completed without damage to the rail and installed per industry standards.
3. **Productivity**, to minimize the exposure of track time for restoring MARTA's operating system back to revenue service.

This section will cover:

1. Moving New CWR from current storage location on mini-rail trains to the mainline work area.
2. Unloading CWR from mini-rail trains, replacement of existing CWR with New CWR, stressing of rail and old rail clean up from the work area.
3. Work activities **not** covered by this procedure include Flash Butt Welding, Thermite Welding, Mini-Rail Train Loading, Track Geometry/String line, Electrical Systems replacement and Cad welding.

Remember to always Stringline the high rail of the curve and record data for the reinstallation of rail and for any final adjustment.

Identify exact limits of rail replacement with Supervision and mark rail for saw cutting

Remove Impedance Bonds, cables and other items sensitive train control equipment and store in a safe location for re-use after rail has been installed.

Complete a Baseline Test for the Rail Ground to Earth Resistance.

- This must be completed after all bond cables have been removed from the rail.

Begin Rail Replacement – First Rail

Upon the arrival of the mini-rail train, Crew will begin to unload the mini-rail train at the work area.

New Rail will be placed inside the gauge of the track on top of 4x4's spanning the second pour plinths.

- This will aid in the rail replacement, the base of the new rail will be higher than the existing DF Fasteners while sitting on the 4x4's.

Once the rail has been unloaded either the low or high rail will be saw cut at the starting point and the removal of Pandrol clips will begin.

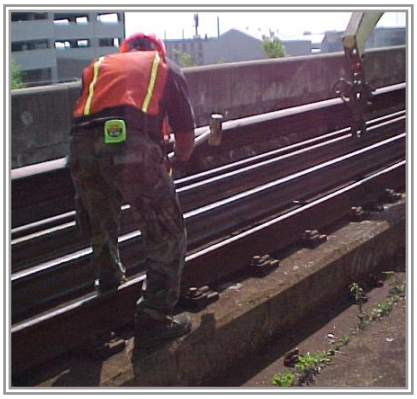
If possible, the first rail to be changed will be the rail farthest from the Third Rail and at the discretion of Superintendent.

When the removal of Pandrol clips has progressed from the starting point the Pettibone will begin removing the existing rail out of the DF Fasteners by picking up on the rail with rail tongs and placing it to the field side.

- This process will continue with the Pettibone working in a reversing move the remainder of the way through the curve until all rail has been removed.
- The last transition joint where the new rail meets the existing rail will be saw cut once the Pettibone has reached this point.

When the Pettibone has removed a sufficient amount of the existing rail from the Fasteners the installation of the new rail will begin.

New rail will be set into the DF Fasteners with the Second Pettibone Speedswing by picking the new rail and placing it into the fasteners.



Once a sufficient amount of rail has been set into the Fasteners every 8 Pandrol clip will be replaced to secure the rail in the fasteners.

This operation will continue with the Pettibone working in a Forward move through the remainder of the curve until all rail has been completely installed into the fasteners.

Once the first CWR sting has been fully placed into the DF Fasteners with Every 8 clip installed, the Thermit Weld will be made at the starting joint.

- This may occur while the second CWR string is being installed taking precautions of any equipment moving or bumping the rail during welding.

Following the completion of the second CWR string, a second Thermit weld will be made at the ending point or transition point where the new rail meets the existing rail.

- This will leave the middle joint open as the stress point for the rail.

If the section of track being worked has a substantial vertical grade then the low point joint will be left open for stressing of rail downhill.

When both welds have been completed rail stressing will begin.

Adjusting and Anchoring Rail

Overview – We anticipate the ambient temperatures to be sufficient for rail movement since rail replacement is being completed during the spring and summers months.

Furthermore to aid in the movement of rail a Hydraulic Rail Puller and Rail Heater will be utilized if necessary.

Record rail temperature and mark quarter points of both sections of rail being adjusted.

Loosen rail clips that have been temporarily fastened at every 8th fastener. From the completed Weld begin clipping the rail towards the open joint. If necessary heat the rail to achieve proper rail temperature and continue to permanently install all Pandrol clips.

Record rail anchoring data on the form, this will include type of adjustment to which zero thermal stress was achieved.

Record rail movement at quarter points of rail being thermally adjusted

Prepare rail ends of middle joint or stress joint for Thermit welding.

If Rail Puller is utilized for Stressing, setup puller at open stress joint. No more than 1,000’ of rail shall be worked with the rail puller.

Mark quarter points, record rail temperature and record length of rail being stressed.

Begin pulling rail until proper pull length has been achieved at quarter points and cut excessive rail out.

Calculate for the proper gap as follows: G = 0.000078L(t-T)/Q

Where: G = gap, in inches

L = Length of rail, in feet

t = 60 degrees Fahrenheit if rail will be anchored in subway

80 degrees Fahrenheit if rail will be anchored elsewhere.

T = temperature of rail in degrees Fahrenheit when being abutted, and anchored.

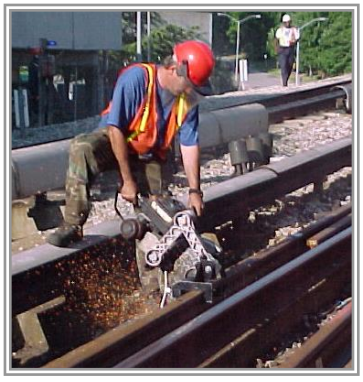
Q = 0.125 inch if joint will be non-insulated: end-post thickness otherwise.

Align rail with abutting rail and adjust rail to be width of gap away from abutting rail

Shorten rail if necessary by saw cutting and complete Thermit weld.

Begin Rail Replacement – Second Rail

All Rails needed for changing the Second Rail shall have been previously unloaded from the mini-rail train and in place for replacement.



Saw cut the rail at the starting point and the remove Pandrol clips.

- The procedure for replacing the Second Rail shall be exactly the same as the procedure for replacing the first rail including the

Adjusting, Anchoring and stressing the rail

When both welds have been completed rail stressing will begin, refer to the Adjust and Anchoring Rail.

Insulated Rail Joints

There are eight (8)-insulated joints to be replaced for the project. Two of the joints on each track, are at the beginning of the rail replacement and will be Flash Butt-welded into the CWR Strings.

The remaining four joints will be cut in the CWR string during the rail replacement process to ensure the Insulated Joints are installed at the exact location they are needed.

These Insulated joints will be installed by cutting out a 19'-6" section of new rail and Thermit welding in the Insulated Joint Plug.

Final Track adjustment

Upon completing the rail adjusting and anchoring the low rail will be checked for horizontal control against the previously recorded string line data.

Adjustments will be made to the low rail as needed to match the string line data by loosening the DF Fasteners anchor bolts and moving the fastener to the appropriate position to match the string line data and tightening the anchor bolts to the proper torque.

Once the low rail has been adjusted the high rail will be adjusted to the low rail by checking the gauge of the track. If the gauge of the track is within in specified tolerances, no adjustments will be made.

If the gauge is out the specified tolerances then the DF Fastener of the High rail will be adjusted by loosening the anchor bolts and moving the fasteners to the appropriate position within the specified tolerances.

When the track gauge has been corrected, the anchor bolts shall be tightened to their proper torque. The same process will be repeated for adjusting cross-level

using the low rail as the reference rail. **This is a sample of how rail can be replaced on the system.**

J. Gauging

Gauging should be done within the Working Zone, but necessary gauging may be done at lower temperatures.

- Only sufficient clips or spikes must be removed to permit gauging and extreme care must be taken so that the rail will not be allowed to buckle vertically or laterally.
- Only sufficient Pandrol clips must be removed to permit gauging and extreme care must be taken so that the rail will not be allowed to buckle vertically or laterally.

K. De-stressing CWR

Operation: De-stressing Continuous Welded Rail

Definition: De-stressing is the operation of removing or adding steel in continuous welded rail, to make the longitudinal thermal force equal (within specified limits) to what it would be if the rail was laid force free at the preferred rail laying temperature.

Method Description:

Continuous welded rail must be maintained so that it is at or near a state of zero thermal stress at a temperature of not more than 10^{o} F above, nor more than 10^{o} F below, the preferred rail laying temperature.

- This range of temperature is known as the preferred rail laying temperature range (PRLTR).
- **The PRLT at MARTA is 90° outside tunnels 75° in covered outdoor platform areas and 60° inside tunnels**

However, continuous welded rail may undergo movement or disturbances, so that it is force free at some temperature outside the preferred rail laying temperature range, as a result of such activities as:

- Track surfacing
- Tie renewals
- Track lining
- Curve rail renewal
- Spot rail replacements (plugs)
- Transposing.

Even if the track is not worked on, the rail can change its force free temperature as a result of:

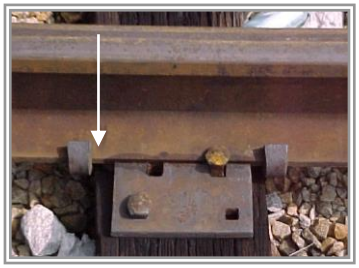
- Rail breaks
- Emergency brake applications
- Worn or defective anchors or Pandrol clips
- Poor quality or insufficient ballast
- Soft sub-grade.

On hills, rail is generally seen to move slowly downhill, which can result in an excessively low force free temperature (compression) at the bottom and an excessively high force free temperature (tension) at the top.

Continuous welded rail that shows signs of not being force free within the preferred rail laying temperature range should be distressed as if its actual rail laying temperature were unknown, whether on wood or on concrete ties.

All engineering officers, supervisors and scheduled work force must be continually alert while on inspection and pay particular attention to the following in order to identify locations that require slow orders and/or distressing and to prevent track buckles.

(a) Extremely **kinky (snaky) rail** that is riding up or out of the tie plates or is crowding the shoulder of the tie plates on curves.



(b) Anchors not tight to the tie and marks on the base of the rail where the rail is moving through the spikes or Pandrol clips.

(c) Ties moving and bunching in the ballast from longitudinal movement. Indications of ties moving in or out of a curve, with ballast gaps at the end of the ties.

(d) Clusters of high spikes, broken clips and poor ties.

(e) Hanging ties on bridge or aerial structure approaches.

(f) Weak ballast shoulders and centers especially at approaches to bridges, road crossings, turnouts, interlockings, sliding joints, and any other fixed locations.

(g) New installations of culverts, turnouts or road crossings.

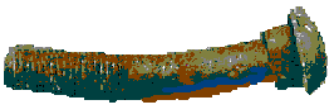
(h) Areas where renewal programs or surfacing has disturbed the track structure. In such areas ensure the slow order extends beyond the disturbed track to prevent brake application on the disturbed track.

(i) Site of a recent derailment, washout, or slide.

(j) Areas of known heavy brake application such as steep grades, permanent slow orders, approaches to interlockings, passing tracks and passenger stations.

(k) Locations of soft sub-grade such as swamps, bogs, or muskeg where the rail moves excessively under traffic causing ties to skew and bunch up.

(l) Areas of buffer rails or any joints adjoining continuous welded rail. Bolts must be inspected for straightness when rail gaps are closed.



(m) Rail gaps that are not closed when the rail temperature is significantly above the preferred rail laying temperature.

(n) Shimming areas (if there are any) must be inspected closely for high spikes and spike killed ties. Anchors must be removed from shimmed track.

(o) Particular attention should be paid to curves in CWR territory. When small tie plates are used, watch for rail canting to the field side.

(p) Particular attention must be paid to welds in curves. Poor alignment of welds will result in heavy, unusual rail wear. Additional excessive forces will be placed on the high rail, causing inside spikes to lift, and track to go out of line.

(q) When surfacing and lining, watch out for lining the curve in or down towards the low rail. Doing so shortens the curve and if steel is not removed it lowers the force free temperature. Surfacing and lining of this nature in cold weather is potentially dangerous as it will be a location for a track buckle in hot weather.

(r) Particular attention should be paid to compromise joints and to locations where rail repairs were performed during winter to replace service failed or defective rails.

(s) In areas of joint elimination caution should be exercised so as not to add steel in the welding process.

(t) In areas of severe corrugation in curves, attention should be paid to rail creepage.

De-stressing may be done by such means as:

(a) atmospheric temperature

(b) heaters

(c) hydraulic rail pullers

De-stressing CWR with preferred rail-laying temperature unknown in wood and concrete tie territory

The following information is required:

(a) The preferred rail laying temperature

(b) The length of CWR to be de-stressed

(c) The maximum expected rail temperature for the day

De-stressing should be planned and completed when the rail temperature is at or below the PRLT.

The following **preparatory work** must be performed:

(a) Measure the length of rail to be de-stressed, determine and mark locations where rail is to be cut.

(b) Make match marks on the field side, on the base of the rail and on the tie plates of unanchored ties on both sides of the point where the adjustment is to be made.

(c) Properly adjust and box anchor all ties for at least 200 feet on each side of where the rail is to be cut.

(d) Prior to separating the rail ends, add additional rail anchors to ensure all ties are fully box anchored for at least 200 ft beyond the de-stressing limits.

(e) In wood tie territory, distribute risers, and in concrete tie territory distribute cording clips (if used), tie pads, insulators and risers.

Some important notes to be remembered while undertaking your de-stressing operation.

The rail must be cut (or joint dismantled if in buffer rail territory) and placed in a position that will permit the rail ends to bypass each other.

The rail must be raised from the tie plates or tie pads and placed on risers. If power vibrators are used, it is not necessary to place the rail on risers.

On wood ties, rail anchors must be removed and spikes raised approximately one inch to allow placement of risers between the base of rail and tie plates.

Risers placed every four to six ties will ensure base of rail is free from tie pads or plates.

In concrete tie areas, all rail clips and clip insulators must be removed and cording clips should be installed on curves approximately every 15 ties.

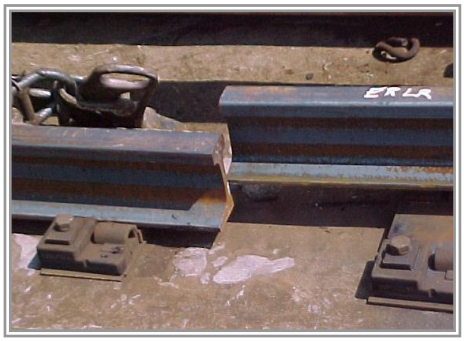
The rail now in the raised position on risers, or fully power vibrated, is force free at the present rail temperature as it is totally unrestricted.

The base of the rail and tie plate or base of rail and clip shoulders must be match marked with a marking pencil throughout the length of rail to be de-stressed.

The position of the rail after being made force free will dictate what action is necessary.

Knowing the length of rail being de-stressed, the PRLT and the present rail temperature, the calculations can now be made as to the adjustment requirement.

De-stressing Steps:



1. Cut the rail
   - Or dismantle the joint or plug rail.
2. Position the rail to permit the rail ends to bypass each other.
   - This allows room for the rail to expand, if it's going to. (you can never be certain)

3a. (On wood tie territory) Remove anchors, and raise the spikes 1-inch.

3b. (On concrete tie territory) Remove rail clips and insulators. On curves, install cording clips at approximately 15 tie intervals.
   - Raising the spikes makes room for the risers and removing anchors permits the rail to move after it is cut.
   - Installing cording clips on curves prevents the track from stringlining.

4. Raise the rail to insert rollers/risers, at 4 to 6 tie intervals, between the base of the rail and the tie plate or tie pad.
   - This ensures that the base of the rail is not touching the tie plate.
5. Lower rail onto roller/risers.
6. Tap rail until no more movement is seen at the match marks.
   - Use only brass hammers (or hammers of other approved soft material) to tap the rail, or power vibrators.
   - Using spike mauls and sledgehammers could damage the rail.
7. Make match marks on the gauge side of the base of the rail and the tie plate or cast shoulder. Intervals not to exceed 400 ft. Marking the gauge side avoids any confusion with the previous match marks made on the field side.
8. Take rail temperature readings.
   - This gives us the force free temperature of the rail.
9. Calculate the “in-track gap” required.
   - Use the de-stressing chart in the job aid, or the De-stressing Graphs from the Recommended Procedures.

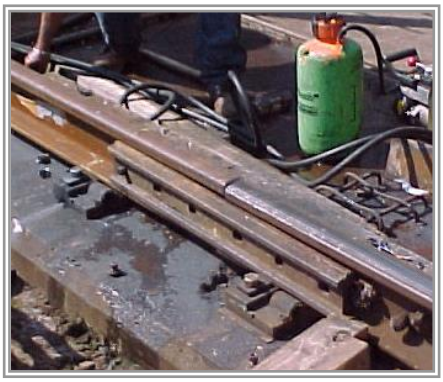
- (If the gap is less than the required expansion adjustment:) Cut the rail end so that the gap is equal to the required expansion adjustment.
- If the rail is to be welded, remember to cut off an additional 1 in for each field weld.

If the gap exceeds the required expansion adjustment: Install a plug rail leaving the required **"in-track gap".**

10. Using a rail heater or a hydraulic rail expander/puller, de-stressed rail by elongating it the required expansion adjustment to close the gap.
    - If welding a plug rail, allow sufficient time for the welds to cool (to <700o F) before elongating the rail.
    - Ensure bolt holes are drilled prior to installing the rail expander/puller (if expander/pullers are used).
11. Check match marks to ensure that the required movement has been achieved throughout the entire length of rail to be distressed.
    - Use brass hammers to tap the rail if the required movement has not been achieved at all the match marks.
12. Raise rail and remove risers.
13. Lower rail back on to tie plates or tie pads.

14a. (On wood tie territory) Tap down spikes.
    - Re-apply rail anchors.

14b. (On concrete tie territory) Install insulators and rail clips. **Do not** remove the cording clips until they are encountered when installing clips. This prevents the rail from string lining.



15. Join the rail ends with joint bars or thermite welds.
16. Remove rail expander/puller (if used).
17. Remove any additional rail anchors that were installed earlier.

18. Obliterate any previous rail laying temperature markings.
    - This avoids any confusion with the new temperature.
19. Paint new "de-stressed to" temperature on rail.

The new temperature should be the PRLT, and is to be in the format: 6-95-112, indicating June, 1995 PRLT = 112º F.

- This is to appear on the field side of the de-stressed rail.

20. Slot joints if the joints will not be welded in the near future.
    - This prevents the joints from chipping.
21. Bond joints on territories with track circuits.

L. CWR Movement

The CWR Movement Chart is used to determine the amount of expansion or contraction that should be expected in a length of rail with a certain temperature change.
This is used to determine the amount of expansion required in order to distress a certain length of rail.

The left vertical column is the length of rail being distressed from 100 to 1500 feet. The bottom row is the temperature difference (the difference between the existing rail temperature and the Preferred Rail Laying Temperature (PRLT).

As an example:
If we were going to distress 1000 feet of rail, the rail temperature is 45ºF and the PRLT for your territory is 95ºF. The temperature difference is 95-45=50.
Find the 1000 foot row on the left column
Follow the row along to the column above the 50-temperature difference reading.
Where the row and column intersect the reading is 4".

- This is the amount of rail expansion needed in order to properly distress the rail to 95oF.
- If the rail is to be welded by thermit welding, an additional 1-inch must be cut off the 1000 foot rail before heating or expanding to make room for the weld.

CWR MOVEMENT CHART IN INCHES

TEMP DIFFERENCE IN ˚F FROM PRLT

FEET	INCHES													
1500	5/8	1-1/4	1-3/4	2-3/8	3	3-5/8	4-1/8	4-3/4	5-3/8	6	6-1/2	7-1/8	7-3/4	8-3/8
1400	5/8	1-1/8	1-5/8	2-1/4	2-7/8	3-5/8	4	4-1/2	5	5-5/8	6-1/4	6-3/4	7-1/4	7-7/8
1300	1/2	1	1-5/8	2-1/8	2-5/8	3-1/8	3-5/8	4-1/8	4-3/4	5-1/4	5-3/4	6-1/4	6-3/4	7-1/4
1200	1/2	1	1-1/2	1-7/8	2-3/8	2-7/8	3-3/8	3-7/8	4-3/8	4-7/8	5-1/4	5-3/4	6-1/4	6-3/4
1100	1/2	7/8	1-3/8	1-3/4	2-1/4	2-5/8	3-1/8	3-1/2	4	4-3/8	4-7/8	5-1/4	5-3/4	6-1/4
1000	3/8	3/4	1-1/4	1-5/8	2	2-3/8	2-7/8	3-1/4	3-5/8	4	4-3/8	4-7/8	5-1/4	5-5/8
900	3/8	3/4	1-1/8	1-1/2	1-3/4	2-1/8	2-1/2	2-7/8	3-1/4	3-5/8	4	4-3/4	4-3/4	5
800	3/8	5/8	1	1-1/4	1-5/8	1-7/8	2-1/4	2-5/8	2-7/8	3-1/4	3-1/2	3-7/8	4-1/8	4-1/2
700	1/4	5/8	7/8	1-1/8	1-3/8	1-3/4	2	2-1/4	2-1/2	2-7/8	3-1/8	3-3/8	3-5/8	3-7/8
600	1/4	1/2	¾	1	1-1/4	1-1/2	1-3/4	1-7/8	2-1/8	2-3/8	2-5/8	2-7/8	3-1/8	3-3/8
500	1/4	3/8	5/8	3/4	1	1-1/4	1-3/8	1-5/8	1-3/4	2	2-1/4	2-3/8	2-5/8	2-3/4
400	1/8	3/8	1/2	5/8	3/4	1	1-1/8	1-1/4	1-1/2	1-5/8	1-3/4	1-7/8	2-1/8	2-1/4
350	--	1/4	1/2	1/2	3/4	7/8	1	1-1/8	1-1/4	1-3/8	1-1/2	1-5/8	1-7/8	2
300	--	1/4	3/8	1/2	5/8	3/4	7/8	1	1-1/8	1-1/4	1-3/8	1-1/2	1-1/2	1-5/8
250	--	1/4	1/4	3/8	1/2	5/8	3/4	3/4	7/8	1	1-1/8	1-1/4	1-1/4	1-3/8
200	--	--	1/4	3/8	3/8	1/2	1/2	5/8	3/4	3/4	7/8	1	1	1-1/8
150	--	--	--	1/4	1/4	3/8	3/8	1/2	1/2	5/8	5/8	3/4	3/4	7/8
100	--	--	--	--	1/4	1/4	1/4	1/4	3/8	3/8	1/2	1/2	1/2	5/8
Degree →	**5**	**10**	**15**	**20**	**25**	**30**	**35**	**40**	**45**	**50**	**55**	**60**	**65**	**70**

Maintaining Existing Rail

The previous lesson has been directed to rail laying and to the procedures that are used to replace rail in excising track.

There are various reasons why rail may require maintenance but not need to be replaced.

This lesson will deal with rail maintenance procedures that are usually of a general nature.

One of the important characteristics of railroad track is that all of its components wear out, except for the sub-grade itself, which tends to improve with age as it becomes thoroughly settled.

These components can be replaced on an individual basis without much interruption to traffic.

The renewal process does not vary in principle from that of a hundred years ago.

- Worn out rail is taken up and replaced.
- Defective ties are singled out and removed.
- New ties are slid into place.
- New ballast, if needed, is added.

Alter a period of time the entire track consists of replacement material.

- On branch lines and short line railroads, a small, well-trained track crew, equipped with relatively simple tools and equipment can usually handle the entire process.

The process by which virtually all mainline track maintenance is accomplished, however, has changed completely because of the necessity to mechanize all aspects of the job in order for work units to be as productive as possible.

Several rail wear problems occur as a result of the stresses imposed by transit cars and locomotives:

- Gauge face wear on high rail of curves
- Rail head flow or crushed rail head on low rail of curves
- Widening of track gauge
- Development of internal and surface defects

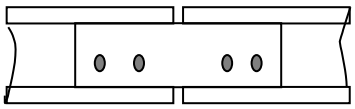
A. Rail Maintenance

Where the rail is moving in one direction, there may be a considerable distance over which each rail moves more or less uniformly.

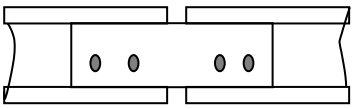
- There may be a point reached where the rail is better secured against longitudinal movement.
- This may be at a turnout, where the adjacent rails are unable to dislodge from a frog or a stock rail connected to a heel block at a fixed position.
- It could be at a crossing, where the anchored ties are so firmly implanted in the ballast and paving that they will not move.

Each rail begins to creep up against the rail immediately ahead of it in the direction of movement. Successive gaps between rail ends close up.

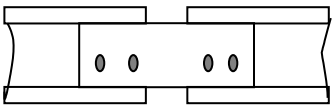
Small gap



Medium gap



Large gap



If the weather turns colder, the rail contracts, and small gaps reappear between the rail ends. The rail still tends to run together, and soon these rail end gaps close tip.

As the weather becomes warmer, there are no openings available for the expansion of the rails. Compression begins to build up in the rails.

- If this compressive force becomes large enough, the track will tend to kink or buckle, as described in the lesson on track alignment.

While the rail has been moving in one direction, and closing up rail end gaps in one area, somewhere back in the opposite direction, the rail end gaps have been increasing.

- In time, the track bolts bearing against the bolt holes in the rails and joint bars restrain the rail so the rail end gaps get no larger.

In this area, trouble may occur when the weather turns very cold. The rails are restrained from contracting, and tension builds up in the rails. This tensile strength tends to pull the rail joint a-part or even break a rail.

A **pull a-part** is a separation of rail ends at a rail joint or a broken rail due to cold temperatures or rail creep.

If enough tension develops, a pull a-part can develop in various ways.

- The most common way is for the track bolts on one end of a joint to shear or break off.

- The rails then separate at this joint, usually leaving an opening of several inches.
- If there is a transverse defect in the rail or a bolt-hole crack, this tension may cause final breakage, again leaving a gap.
- The same thing can happen if one or both joint bars are cracked.
- Both buckled track and pull a-parts can be dangerous. In some cases, serious derailments result.

B. Understanding Why Rail is Moving

In order to determine a good solution for troublesome rail creep or rail movement at a particular location the reasons the rail is allowed to move must be determined.

Not only should the result of rail movement as in a buckled track or pull a-part be fixed, but also such a problem should be prevented from reoccurring in the future.

Consider why the rail tended to run in the first place.

It might be natural to assume that the Pandrol clips or rail anchors have failed to hold.

- Occasionally, Pandrol clips or rail anchors will slip on the rail or be broken or missing.
- This may happen if the Pandrol clips or anchors have been overdriven or have been reapplied too many times, so as to lose their holding power.

It can also happen if the base of the rail is corroded at the time the anchors were applied.

- If this happens, evidence of rail anchor slippage can be seen on the base of the rail.
- Coronation of the rail base can also cause the Pandrol clips to become loose.

In most cases, rail anchor slippage is not the cause of the movement of the rail. Various amounts of longitudinal rail movement are sometimes caused by failure to apply part or all of the anchors so they are firmly contacting against the side of the tie.

- Also, Pandrol clips become loose, missing or sprung over time and will lose their holding power.

Where more substantial amounts of rail movement takes place it is likely that movement of the anchored ties is taking place.

- If movement of the ties is taking place, either the ballast is not adequately restraining the ties or too few ties are anchored, and it is unreasonable to expect the ballast to provide all needed holding power at these few ties.

If the ballast is not doing an adequate job it may be due to insufficient ballast in the tie cribs.

It could also be caused by disturbed track, such as track which has been raised or has had substantial tie renewals thereby reducing the bond between the ballast and the ties.

Rail Creep

Rail tries to lengthen or creep, forcing ties and ballast out of line and developing stresses tending to make the track buckle sideways.

- Therefore, heavy-tonnage track is equipped with rail anchors.

- Or the track is equipped with Pandrol clips which act as both spikes and rail anchors.

As many as four rail anchors per tie may be required in places where temperature changes, heavy grades and train breaking, particularly with loaded traffic in one direction, conspire to make the rail run.

Problems will develop when the rail anchors or Pandrol clips fail to prevent longitudinally movement under traffic.

- If this happens, rail will creep a small amount under each successive train.

With single direction traffic as in multiple track main lines, this will not frequently be in the direction in which the traffic moves. Where the traffic movements are fairly well balanced in both directions, the predominant tendency will be towards the bottom of opposing grades and away from the crest of opposite grades.

Rail Adjustment

If rail requires readjustment, there are different ways it can be done.

(a) One way is to move each rail back to its former location, restoring proper rail end gaps as the work proceeds, then providing additional rail anchors and, if necessary, additional ballast.

(b) Another way is to insert a rail that is just few inches shorter than the one replaced in the vicinity of the tight joints.

(c) A rail that is a few inches longer than the one replaced can be inserted in the vicinity of the excessive gapping.

Local adjustment of rail end gaps can be made in the vicinity of each of these corrections, and adequate restraint such as rail anchors or new Pandrol clips are applied.

Sometimes, only one of these corrections is made.

- Remember because the rail is moving tight joints may mean that there are gapping joints elsewhere or vice versa.

If the corrective action be to address tight joints, first inspect other joints to see if these tight joints have been accompanied by gapping joints elsewhere.

- The same would be true of addressing gapping joints: be alert to tight joints elsewhere.

Sometimes, the movement of rail is detected before a pull a-part or buckled track occurs.

- Applying additional rail anchors or replace broken or sprung Pandrol clips and/or additional ballast to cribs and shoulders may be sufficient to prevent such problems form occurring.

There are various ways that potential track buckling or pull a-part situations can be detected. One way is to check rail end gaps looking for a consecutive series that is either greater or less than the average for that particular temperature.

- According to the MARTA Track Safety Standards rail joint gaps should be 3/8" to 5/8". Report any rail gap over 5/8"
- Remember, that if one of these conditions exists, it may be compensated for by the opposite condition elsewhere.

If the rail anchors are generally backed off and away from the sides of the ties, this would indicate that the rail has moved in the opposite direction.

- It might be a situation where the anchored ties had been moved ahead, but a recent series of train movements in the opposite direction or temperature change, has caused the rail to move back towards its original position.

Inspection of the edges of the rail base in the vicinity of unanchored ties can also provide clues. When rail slides through the tie pads or plates, marks from the pad or plate shoulders may be present on the edge of the rail base.

- This is also true for Pandrol clips. If the rail has moved or is running, scrap marks will be seen on the rail base in the direction that the rail is moving.

Frozen joints

It is possible for jointed rail to be under considerable compression or tension without unusual rail end gaps.

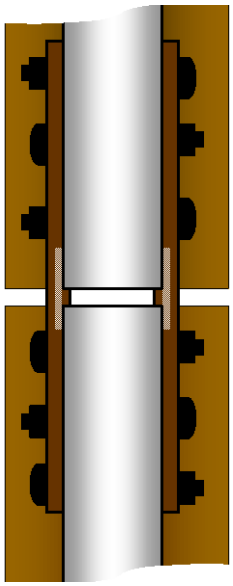
- Heavy rusting or some other high friction condition can prevent sliding between the joint bars and the rail ends.

When this happens, the joint is said to be **frozen.**

- This condition can be present in hot weather as well as in cold weather.

One of the greatest hazards caused by frozen joints occurs when track is disturbed by raising or tie renewals in hot weather.

- The presence of gaps between rail ends can create a belief that there is no danger from compression during the heat of the day.
- The time to check this is in the morning before the rail warms. The cool temperatures at night will allow the rails to lose some of its compressive tension.



If the joints are not frozen, the gaps will tend to close up in the heat of the afternoon.

- If this has been happening on previous hot days, there will be shiny marks visible on the tops of the joint bars between the rail ends that are invisible during the cool of the morning.

- If shiny marks are found on most open joints, indicating sufficient rail movement during the hot periods of previous days. It is reasonable to presume that excessive rail compression is unlikely.

If there is a substantial number of joints where the tops of joint bars are rusty before the sun has heated the rail, further check for frozen joints should be made.

- Try loosening the bolts in a joint enough to relieve the bolt tension then loosen the joint bars.
- If this closes or reduces the rail end gap, it indicates that the rail is in compression.
- Taking the joint apart and cleaning it with a wire brush, to get rid of the rust, and then applying a lubricant will allow the rail within that joint to move freely.

This should then be done at additional joints on both rails until no more expansion occurs. As the rail temperature increases, this should be repeated at intervals throughout the day.

C. Effects of Temperature Changes on CWR

A very different situation exists with CWR, regarding stresses within the rail.

When CWR is laid, it is expected that the rail will not expand or contract.

- This means that most of the time the rail will be under stress, either from compression or tension, depending on the rail temperature.

Very extensive Pandrol clipping or anchoring and ballasting are necessary to restrain the rail so that it neither buckles in hot weather nor pulls a-part in cold weather.

- Anchoring in this content can mean conventional rail anchors as are used hear in the rail yards or could mean Pandrol clips which perform the same function as standard rail anchors and spikes out on the mainline tracks.

Furthermore, the usual practice is to let the rail find its normal length while it is at a median temperature.

- This will be approximately the middle temperature of the rail in the range of maximum and minimum rail temperature that can be anticipated within the course of the year.
- This is called the Preferred Rail Laying Temperature (PRLT). That temperature here at MARTA is 90˚ outside tunnels, 75 ˚ under station canopy's and 60◦ inside tunnels.

If the rail is restrained through clipping or anchoring and ballasting while at or close to the median temperature, the extremes of stress will be lessened.

- Some railroads specify that CWR be adjusted to a temperature somewhat higher than the median temperature.
- This is done because it is felt that the track can withstand higher stresses in tension at cooler temperatures than in compression at hotter temperatures.

If the rail is laid at a time when its temperature is not close to the specified temperature, and if there is no rail heating or cooling equipment to bring the temperature to this range, the rail will have to be readjusted later.

- This readjustment must be done when the rail is close to the specified median temperature.

Preventing Buckling and Pull A-parts in CWR

It is much more difficult to find signs of high stress in CWR than in jointed rail.

The rail end gaps that frequently provide evidence of the condition in jointed rail are not present in CWR.

- Even a small amount of movement of rail or ties can produce high stresses.
- In the case of compression, sometimes a wavy effect will be evident before actual buckling takes place.

If the CWR strings are joined by conventional joints, sometimes excessive tension may cause a greater than normal opening of the joint.

- This may also indicate that the track bolts are being bent.

Where CWR strings are connected with conventional joints, occasional checking of at least one bolt per joint for unusual wear or bending is advisable.

- If the bolts fail frequently, replacing the Pandrol clips or installing field welds might be considered.

Aside from these signs which do not always occur, the best protection is through prevention. Proper thermal adjustment is but one of the things that should be done.

- Proper rail anchor application is essential so all anchors are restraining these forces.
- Proper installation of Pandrol clips is essential so that the stresses applied in the track are shared by all the ties or pads in that area.

A full ballast section is as important as the anchoring and clipping. Avoiding track raises and extensive tie renewals in very hot weather is another important prevention.

Changes in temperature can greatly affect the integrity of CWR. Typically, significant increases in rail temperature can cause buckling-prone conditions, and significant decreases in rail temperature can cause pull-apart prone conditions. We cannot quantify the specific temperatures that would cause a buckling-prone condition or a pull-apart prone condition.

When buckled track is suspected slow order track to 25 MPH and monitor every train over the affected area. Notify Rail Service Control Center and Track & Structure Management ASAP.

When buckled track has occurred and the deviation in alignment still falls within Class 1 Track Safety Standards or higher for a 62’ chord measurement slow order the affected area to 10 MPH, monitor every train over the affected area. Notify Rail Service Control Center and Track & Structure Management ASAP.

If the buckled track fails to meet even Class 1 Track Safety Standards for alignment using the 31’ or 62’ chord measurements, take the track out of service and notify Rail Service Control Center and Track & Structure Management ASAP.

Particular attention should be given to periods of temperature fluctuations. In the event daily cycles of extreme temperature fluctuations occur, consideration shall be given to repeated inspections.

- We cannot quantify the specific temperatures that would cause a buckling-prone condition or a pull-apart prone condition.

Physical track inspections are to be performed to detect pull-a-parts in cold weather or buckled track in hot weather. At a minimum, these procedures shall address inspecting track to identify –

1) Locations where tight or buckling rail conditions are likely to occur;
2) Locations where pull-a-parts are likely to occur;
3) Locations where track work, such as replacing ties, lining & surfacing track etc. have recently been performed.

For the inspection of CWR, the following areas are to be addressed:

Rail

- Canting or tipping of the rail
- Rail crowing the shoulder of the fastening system
- Rail lifting or riding up in the fastening system
- Scrape marks on the rail indicating longitudinal rail movement
- Uneven wear patterns on the rail gauge face or running surface
- Excessive longitudinal rail movement at switch points & stock rails causing misaligned switch points

Rail Joints

- Pull A-parts
- Track bolts that are bent, broken or worn
- Heavily worn fishing surfaces of the rail joint
- Frozen joints (rail end gaps at rail joints that are open when the rail is hot & closed when rail is cold)

Rail Fasteners

- Tearing, lifting or separating of the Direct Fixation fasteners
- Missing rail clips or rail anchors

- Rail anchors that are away from the edge of the tie
- Resilient fasteners that are loose, missing or broken along one side of the rail
- Skewed gauge rods

Crossties

- Skewed ties
- Hanging ties, particularly at approaches to bridges or aerial structures
- Clusters of defective ties or pads
- Skewed gauge rods

Ballast

- Churned (recently disturbed) ballast or displaced ballast
- Gaps in the ballast at the ends or sides of ties
- Bunched up or piled ballast at the ends or sides of ties
- Insufficient ballast shoulders

Track Geometry

- Misalignment, kinks, buckles or flat spots in the track
- Changes in alignment with temperature changes
- Irregular gauge
- Pumping track

Other Areas of Concern

- Track that has recently been worked (lined, surfaced, ties replaced)
- Past derailments, buckled track or flat alignment spot locations
- Steep grades (uphill or downhill)
- Locations subject to heavy acceleration or braking (platforms, speed changes, interlockings)

Curves may shift inward during cold weather even though no work was done.

This occurs because the rail temperature is lower than the rail neutral temperature, placing the rail in tension as in a pull-a-part.

- This condition can be identified by ties pulling inward, leaving a gap in the ballast on the high side of the curve or a flat spot in the alignment in that curve.

Pay close attention in cold weather to announcements by RSCC or YTS of a track circuit being down. This may indicate a broken rail or a pull-a-part in that area. Investigate immediately.

Longitudinal Rail Stresses from Trains

In addition to the longitudinal stresses induced by changes in rail temperature, trains can generate huge longitudinal forces. When trains accelerate or brake the momentum of the train is translated into longitudinal forces in the rail. These forces can be very high. For rail transit systems the effects of these forces can be compounded since trains stops and starts occur nearly at the same locations, in the same directions with every train. Locations such as stations, speed changes and interlockings are particularly impacted. Automatic Train Control systems (ATC) further exasperate these effects, since it will automatically brake and accelerate all trains at exactly the same locations, every time: whereas with manually controlled trains each train operator will brake/accelerate trains in different locations and rates.

Longitudinal Rail Restraint

This section discusses the large forces that can be generated in CWR. When CWR is in the track these forces are offset with four restraints: pad or rail seat friction, joint bar restraint, fastening system and ballast.

At properly maintained rail joints the longitudinal restrain of the rail is approximately equal to the clamping force of each bolt. A properly torque bolt provides about 25,000 pounds of restraining force. For a rail joint with 4 bolts installed, this equates to 100,000 pounds of restraining force: (150,000 pounds for 6-hole joint bars.) The key point is a “properly maintained” rail joint.

Loose rail joints do not provide as much restrain as is possible with tight rail bolts.

The fastening system provides the primary resistance to longitudinal rail forces and movement.

- The Pandrol rail anchor / fastening system can provide significant longitudinal restraint, if properly maintained. Loose or missing Pandrol clips can greatly reduce restraining capacity.

With many resilient fasteners the rail alignment and longitudinal restrain are combined. The longitudinal restrain capacity of a well maintained fastening system is approximately 5,000 pounds per tie or fastener.

Rail should be maintained at proper thermal adjustment, regardless of the type of track construction. Sudden failure of the fastening system can occur if the rail is not properly adjusted. The high forces will also be transferred to the structure, causing permanent damage.

- Sun-kinks and pull-a-parts can also occur on these track, the results are usually take more resources to repair, with symptoms such as loss of gauge and failed DF fasteners.

On ballasted track the longitudinal forces from the thermal rail expansion and contraction are transmitted from the rail fastening system to the ties. The ties then transmit these loads to the ballast. At times this can cause the rail can lift the ties out of the road bed.

Well maintained ballast with well maintain fastening system provide approximately 1,300 pounds per anchored tie.

- This can be significantly reduced if there is insufficient ballast, the ballast is not well compacted, ballast that has poor interlocking properties is used, or if the track is not firmly tamped.
- With fouled or dirty ballast water can make a very slippery surface for the ties to sit in allowing them to move laterally.

Neutral Rail Temperature

Neutral rail temperature is the rail temperature at which the rail is not in compression. Initially, it is the rail temperature which the rail was laid. At MARTA that temperature is 90° outside of tunnels and 60° inside of the tunnels and 75° under the rail stations canopy.

Ambient Temperature versus Rail Temperature

All references to temperature should refer to rail temperature. In hot weather, the rail temperature is generally greater than the ambient (air) temperature. For the purposes of planning or scheduling track work in the short term in hot weather, it is appropriate to use the predicted ambient temperature plus 30 °F to estimate the rail temperature. In cold weather, the rail temperature is essentially equal to the ambient temperature, and no such adjustment is necessary.

Correcting Buckled Track

It is entirely possible that you may, at times, be faced with a situation where the track has buckled.

- Your first responsibility in such instances is the protection of train traffic through that area.
- The track alignment may be distorted enough to make it unsafe for train operation at any speed. Or the alignment could be less severe and suitable for operation at a reduced speed.
    - This can be determined by first looking in the MARTA Track Safety Standards.

The alignment defect might only be slightly irregular and still be adequate for normal speed.

- Consideration should be given to the possibility of the rails, while still being under compression, may buckle further under a train.

Regardless of the situation that exists, your first concern should be whether speed and other restrictions have been placed on train operations and whether they are adequate. A train derailment can occur if the track is unstable.

- This can only be done by looking in the MARTA Track Safety Standards.

Track personnel's next concern should be whether trains are being delayed by the track conditions and what can safely be done to minimize such delays. Cooperation with Rail Control is essential for train re-routing.

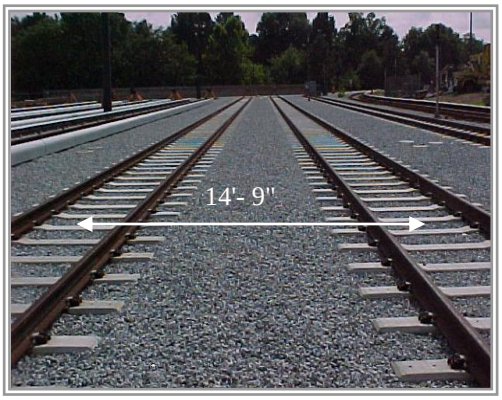
- A decision may be made to try lining the track back to its proper alignment and to allow train to pass at reduced speeds.

Unless the rail temperature has dropped significantly since the track buckled, this will probably be difficult. Furthermore, the track will tend to be unstable, and likely to buckle again.

It is important to keep the track in a condition that will permit operation of trains even at slower speeds. You might consider lining the track on both sides of the distortion to reduce its severity.

The MARTA Track Safety Standards for track alignment should be used to provide as to what is required for various speeds.

If Track personnel choose to line the track on one or both ends of the distortion as a temporary or even permanent solution, be certain not to create a close clearance condition with trackside structures or earthwork, or a close track center condition with an adjacent track.



- MARTA track centers are a

minimum distance of 14 feet 9 inches.

Whether it is done initially to alter the track alignment to satisfy immediate operating requirements, the track will have to be restored to its proper alignment and stabilized.

- Plan on cutting some rail out unless the track buckle was caused by greatly insufficient ballasting or anchoring.
- This may be necessary even if the lack of ballast or rail anchors was the cause.
- The condition may have permitted too much longitudinal movement of rail into the affected area.

If jointed rail is involved, cutting can be done at any convenient rail joint.

- It could involve installing a shorter rail or possibly cutting off one of the rails in the track so the second bolt hole of the rail end becomes the first bolt hole.
- This will have to be repeated on the other rail of the track.

The situation may be a little different if CWR is involved. If conventional joints join the CWR strings, it may be desirable to make the adjustment at the closest joint.

- This will avoid installing additional joints in track.

If field welds are used, the cutting may take place at the affected location. The cut ends can then be joined by the preferred method.

- Care should be taken not to cut out more rails than is necessary to correct the condition.
- If the rails must be stretched to rejoin them, a pull a-parts may be likely in cold weather:

After the rails are cut and connected, rail clips will need to be reinstalled.

- It might be necessary to apply additional anchors.
- Any disturbed ballast should also be restored and the ballast consolidator is used to compact the ballast to stabilize the track.

Correcting Pull A-parts

Pull a-parts may occur in either jointed rail or CWR. They are most likely to occur during periods of severe cold weather. The pull a-part may involve:

1) Sheared off bolts
2) Broken rail
3) Broken joint bars
4) Broken welds in CWR

If a broken rail is involved, the type of rail break defect should be identified.

- The rail may have to be replaced in accordance with MARTA Standards.

Also, the break could be close enough to a joint to cause a too short piece of rail in the track. MARTA standards recommend a minimum length of 14 feet per rail.

- Verify the company's standards from the MARTA Track Safety Standards

If the rail must be replaced or if the gap is excessive, it may be advisable to only partially fill the gap created by the pull a-part.

- This would apply to these situations involving very cold weather.

The insertion of too much rail could result in buckling during hot weather.

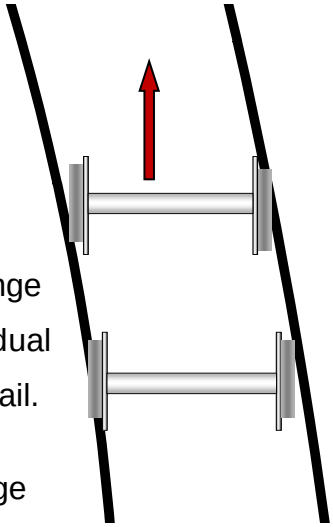
- Heating the rail could then close the remaining, balance of the gap.
- A rail heater, as is shown in the picture, will work, so too will the manual way to heat rail by using rope soaked in diesel fuel and lit.

After the rails are bolted together, the rail clips will have to be replaced or readjusted.

- Such additional anchors would be particularly helpful in correcting a pull a-part caused by excessive strain on bolts rather than a pull a-part allowed to occur by another track defect such as broken joint bars.

An alternate course of action, if the pull a-part was a joint failure in CWR, would be to install a field weld.

D. Curve-worn Rail

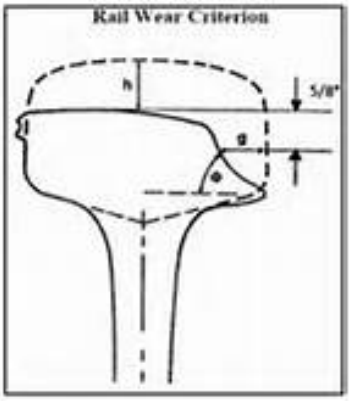


It has been shown that as trains travel around a curve, the lead wheel of each truck on the high or outer rail must constantly be deflected from the straight line path it is attempting to follow.

- This constant abrasive action between the wheel flange and the gauge side of the rail head causes a gradual wearing away of the steel on both the wheel and the rail.

So far as the rail is concerned, this wearing away of the gauge side of the rail head might be carried on until too much of the rail head is removed and that the strength of the rail is threatened.

- As a practical matter, if the amount of the wear becomes that extensive, track gauge is usually widened.
- Some of this gauge widening may be attributed to spreading or canting of the tie plates, but much of it can be caused by the rail wear.



Curves must be elevated on the outer rail to protect trains moving at the maximum authorized speed.

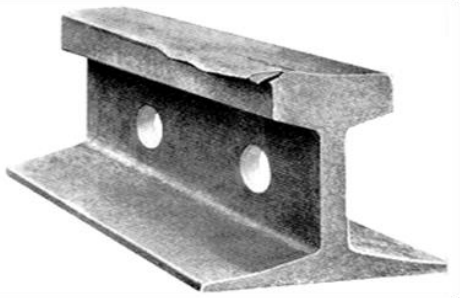
Yet many curves have a considerable number of trains operating over them at much slower speeds.

- When trains operate at these much slower speeds, a good deal more than half of the axle weight may be placed on the low or inner rail because of the car being tilted to that side by the elevation.

This does not place large flange loads against the side of the low rail. Instead, the loads placed by the treads of the wheels are on the top of the rail head and tend to be large.

This has a cold rolling effect on the rail head, which tends to flatten it.

There is also a tendency for the steel to flow outward, beyond the edge of the rail head on the field side loaning a lip.



These lips often form on the field side of the high rail as well, but not usually to the extent that they do on the low rail.

Development of Defects Introduction

There are several factors that can influence the expected duration of rail service. The service life is affected primarily by the chemical composition of the rail, track maintenance programs, speed, and tonnage. All of these factor into the development of vertical and lateral head wear, plastic flow or deformation of the rail head, and development of rail defects.

- **Track maintenance programs –** Track maintenance programs consist of any track maintenance procedure that can ensure the track can maintain adequate support to reduce the amount of rail flexing, provide proper friction control, and provide rail profile maintenance that will considerably influence the rail service life.
- **Wear –** Lateral wear occurs primarily on the gauge face when the rail is located on the high side of a curve from the presence of high-wheel flange force. Vertical wear occurs on the rail head running surface from the wheel/rail interaction during cyclical loading and rail grinding patterns.
- **Plastic flow –** Plastic flow or mechanical deformation of the rail head can occur on high or low rail, and is normally associated in curves that carry higher axle load operations. Plastic flow is a result of wheel/rail contact stress that is exceeding the material strength of the rail steel.

Rail defects – Rail defects develop in any type of rail, or rail welds, as a result of several conditions.

- These conditions normally will originate from the rail manufacturing process, cyclical loading and impact from rolling stock, rail wear, and plastic flow.

The development of rail defects can be influenced in modern steel through an extensive maintenance program that will prolong the timeframe before the rail is subjected to the effects of excessive wear and plastic flow.

- This would include friction control methods and proper rail profile. However, it is impossible to accurately predict rail service life or defect development.

Rail Loading and Stressing

Internal rail defects normally require certain forms of rail stresses to initiate progression and develop to a detectable size defect. Listed below is terminology that can be used to describe the planes of stresses in rail:

- **Vertical Plane** – stresses progressing in a vertical direction normal to rail length
- **Horizontal Plane** – stresses progressing horizontally along the rail
- **Transverse Plane** – stresses progressing transversely along the cross section of the rail

Rail Loading at the Rail/Wheel Interface

Vertical Loading – Loading forces applied by the wheel tread under normal train operation. They are normally characterized into three components referred to as static load, dynamic load, and impact load.

- **Static load** is the equivalent to the gross weight of the railcar divided by the number of wheels (i.e., 20-ton railcar with 8 wheels has a static load of 2.5 tons per wheel). The static loading can be influenced by track curve super-elevation.

- **Dynamic loading** is the increase of static load that results from train speed. This is a result of vertical dynamics associated with the car/truck interaction with the track geometry (curve).
- **Impact loading** is the additional increased loading over static and dynamic that occurs when a wheel travels over a significant rail head irregularity, or the wheel contains a flat spot.

(Note: Actual vertical loading of the rail can be determined by the addition of the above components and can be considerably greater than a normal static load.)

Lateral Loading – The load forces applied by the wheel flange to the high rail in curved track. This is a result of wheel/truck curving forces. In sharp curves, lateral loading is normally stable throughout the curve.

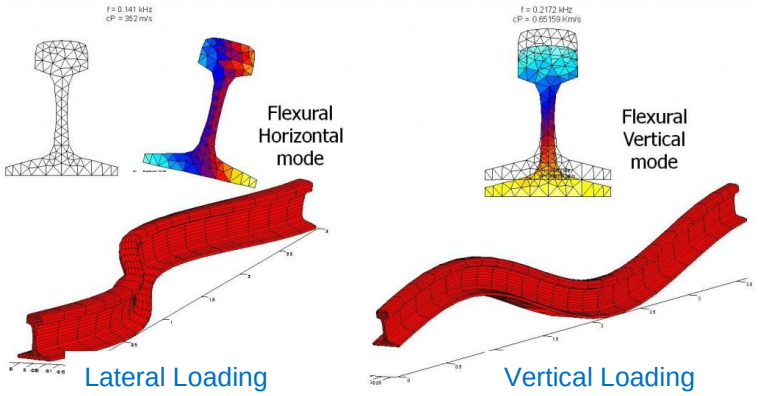
- However, in a shallow curve or tangent track, lateral loading can occur as a result of truck hunting.

Creep – Load forces that are generated at the localized rail/wheel interface by the rolling action of the wheel.

- Longitudinal creep forces result from traction applied to the rail head by the wheel.
- Transverse creep forces result from lateral movement of the wheel during truck hunting.

Rail Stresses

Bending Stress – Are the bending of the rail that occurs from vertical wheel loading and lateral wheel loading. Vertical wheel loading normally results from loading



Lateral Loading Vertical Loading

between the tie supports, and causes tensile longitudinal stresses in the rail base area and head/web fillet area.

- Lateral wheel loading applies tensile longitudinal stresses in the rail web area and head/web area of the rail field side.

Thermal Stress – These stresses occur in continuous welded rails due to thermal expansion and contractions that occur as the actual rail temperature increases above or reduces below the rail neutral temperature.

- When the rail temperature is above neutral temperature, compressive longitudinal stresses are established.
- When the rail temperature is below neutral temperature, tensile longitudinal stresses are established.

These stresses can drastically influence rail flaw development.

Residual Stress – These stresses are a result of the manufacturing process, particularly from roller straightening and head hardening.

- They can also result from the welding of rails because of the different expansion and contraction of the steel that occurs during the weld process.

Residual stresses can be found in any location within the rail section and can exhibit high tensile stresses that can result in rail failure.

Defect Development Identification:

Defects will development in relation to the planes of the rail section.

- These are identified as **transverse, vertica**l and **horizontal** planes of development.

The defects that develop in a transverse plane in relationship to the rail section are normally internal in origin and are not visibly identified until the defect progression penetrates the rail head, web or base.

Internal transverse defect size can only be identified visibly by breaking the cross-section of the rail in a press.

- After the rail is broken, a transverse defect is measured against the cross-sectional area of the rail head. If half of the rail head cross-section shows signs of defective growth, the defect is called a 50-percent fracture.

When the defective portion of the rail is closely examined, certain characteristics provide information that will allow the type of growth identification the defect had experienced. Transverse growth is normally referred to in three types of classifications:

Normal Growth – Defect development over a period of time in gradual stages. Normal development is typically progressive and can be uninterrupted.

- The defect will show a smooth and polished fracture with no granular structure. There may also be a number of identifiable smooth granular growth rings.

Rapid Growth – Signifies recent development in numerous small stages. The small, polished, well-defined fracture is surrounded by a rough granular surface, which shows the outline of several growth rings of gradual increasing size.

Sudden Growth – Signifies recent development in a few large stages. The small, polished, well defined fracture is surrounded by a rough granular surface, which shows the outline of one or two growth rings.

- The distance between rings will increase directly with the rate of growth.

Multiple Stage Ruptures - Defects that develop in an oblique, angular, or longitudinal direction in relationship to the rail section can also produce identifiable stages of development, referred to as multiple stage ruptures.

- This is often seen in bolt hole breaks, base breaks, and head and web separations.

When a longitudinal or angular defect shows signs of various stages of development, each is considered a separate stage of development.

- This is normally identified by the presence of a preexisting identifiable fatigue condition along with another growth stage, or complete failure, referred to as secondary development.

There may also be a previously oxidized portion within the break and a normal granular non-oxidized portion of break.

- The oxidized portion may represent the initial stage of development, and the normal granular non-oxidized portion will normally represent the secondary stage of development.

It is possible to have more than two stages of development before complete failure of the defect.

- If a preexisting fatigue condition is not identified on the fracture face, the failure is commonly referred to as a “sudden rupture.”

E. Prolonging Rail Life

In Curves, particularly sharper curves, there exist the conditions which shorten the rail life. Here are some of the things that can be done to prolong rail life.

Heat Treated rail

There are various ways in which the life of rails on curves may be increased.

- One way is to install specially made rails on curves that are more resistant to these types of wear than ordinary rail.
- This wear resistant duality can be attained when the rails are manufactured by heat treating or by varying the chemical content of the steel.
- These rails are considerably more expensive than ordinary rails.

Rail Lubrication

Rail lubricators are an effective way to reduce the gauge cutting of the high rail by reducing flange to rail head friction.

The most common type of is attached to the rail ahead previous to the curve or curves to be protected.

- The wheels of passing trains depressing a plunger or lever to activate the lubricators. This causes grease to be deposited on the gauge side of the wheel flanges.
- The wheel flange in turn carries this lubricant around the curve, depositing it on the gauge side of the rail head.

Transposing Rail

Assume that full headed rails are installed on both the high and low sides of a curve.

- The normal wear patterns develop on both the high and low side.

At some point the rails are removed from the track and the rails which were on the high side are installed on the low side in the same order. This is called **transposing.**

The rails that were on the low side are placed on the high side in like manner.

The gauge side of the former high rail is now the field side of the low rail.

The gauge side of the former low rail is now the field side of the high rail.

- This practice is known as transposing rail.

Transposing permits more total wear to develop on curve rails before they must be replaced.

- It is usually not feasible to let the wear on the gauge of the high rail develop to its maximum limits prior to transposing.

In determining when to transpose rail it is necessary to carefully watch the field sides of the rails for signs of metal flow that indicate the start of a lip.

- It is not good practice to reinstall rails with a substantial lip on the gauge side.
- The lipping, when transposed to the gauge side, will start to break off causing the rail head surface to become broken and pitted.

Where the practice of transposing is carried out, it is frequently possible to permit more wear to occur after transposing than before transposing.

Since it is necessary to remove both rails at the same time when transposing, the tie pads or tie plates are not removed.

- The rail clips or the rail-holding spikes are removed from each rail.

Jointed rail can be transposed with the use of an on-track crane.

- It is helpful to have one extra rail to begin the job. This makes up for the different lengths of rail that occur between the high rail and the low rails of a curve.

Suppose the first rail removed is on the high side and just before the point where curve wear has developed. The extra rail is installed on the high side to replace it.

- The rail removed from the high side is carried ahead to the point where the first low rail has been removed.
- This rail is then installed on the low side.

The first low rail to be removed is carried ahead and it becomes the second rail installed on the high side.

This transposing of jointed rail is continued through the cure as needed. However, in doing so the track personnel should be alert to maintaining a good staggering of rail joints throughout the curve.

- Check the MARTA Track Safety Standards for correct rail stager.

The particular curve being worked may have had shorter rails previously installed to maintain proper rail joint stagger.

- When transposing, placing the shorter rails on the opposite side may create poor joint stagger.

It may then become prudent to move these shorter rails elsewhere or replace them with longer or full-length rails in order to maintain good joint stager.

The transposing of CWR requires specialized track equipment to handle the rails.

- A swing type crane or rough terrain crane with long axles permitting the rubber tires to ride on the tie ends will do a good job.

It is not always practicable to measure the total length of rail to be removed on both sides accurately enough to get the lengths cut out to be identical.

- Rail expansion or contraction, after removal, can further complicate this.

It is more likely that one length of CWR removed will be slightly longer than the other.

- One extra rail will be required at the end of the job to install on the side where the longer length was removed and the shorter length installed.

Two passes will have to be made.

- Installing one side on each pass.

Sometimes variations on the basic transposing practice are used.

Suppose that too much lipping and flattening, has developed on the low side rail to make it suitable for transposing. Yet, the high side rail is suitable for transposing.

- It may be advisable to provide enough additional rail to be installed on the high side, then transposing the former high side rail to the low side and disposing of the low side rail.

In another situation, the rail head wear on a curve to the point where track gauge is at the maximum limit and the low side rail is unsuitable for transposing.

Replacement rail is not always readily available. Sometimes expediency is to turn each of the high side rails end for end to end (for stick rail), reinstalling them on the high side.

- It is not recommended that rails be left in the track for long periods in this condition, as the total wear on the rail head can be extreme.
- Look at the joint bars on heavily warn rail, there may be a shinny mark on the tops of the joint bars where the wheel from the train is striking or rubbing the top of the joint bar.
- If this is happening it is a sure indicator that there is substantial head wear loss of the rail and needs to be reported to your supervisor ASAP. (This condition can cause the wheel from the train to rise up into the air so that the wheel does not make full contact with the rail head possibly causing a train de-railment.)
- It can be a means of temporarily preserving track gauge while replacement rails are being obtained.

F. Correcting Wide Gauge

The forces that cause gauge widening and the allowable limits of gauge widening are established in the MARTA Track Safety Standards for Track Alignment and Gauge.

Gauge in Curves

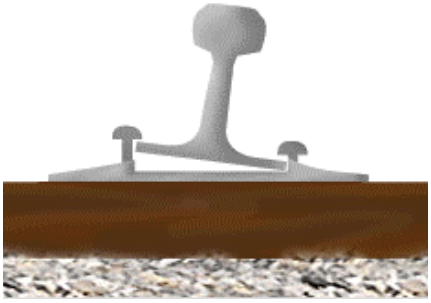
In addition to the increases in gauge, which are due to wear on the gauge side of the rail head, the other major causes are spreading of the gauge and canting of the rails and rail fasteners.

In many cases where spreading or canting occur they develop at a slow enough rate to permit correction during the rail replacement process.

- Our concern with gauging as a separate operation involves the situations when correcting wide gauge becomes necessary between rail renewal cycles.

In most cases, it is a combination of conditions that allows track gauge to widen to the maximum track gauge limits specified by MARTA.

- It is important that this be remembered when resetting the gauge.



For instance, suppose there is wear on the gauge side of the rail head of the high side rail of a certain curve.

- This defect is not yet severe enough to justify replacement of the rail.

The rail and pads or tie plates have been spreading. The combination of these conditions results in allowing the gauge to widen to the maximum allowable track gauge specified by MARTA or the FRA for a class 4 track.

- It is decided to re-spike, re-lag or re-anchor the rail and tie pads or plates to correct the gauge. Or to correct the gauge by adjusting the pads themselves.

When this is done, the gauge is restored to standard track gauge of 56-1/2 inches.

- Remember, the high rail is curve worn, and it is to this rail that gauge is measured.

- Also remember, the low rail in a curve is the gauge rail, it will be the one to be adjusted to correct gauge.

When it becomes necessary to replace this rail, if a full head rail is installed without readjusting the pads or tie plates, the gauge will then be tight (less than 56-1/2 inches). It therefore becomes necessary to re-gauge the track again, this time outward.

- This not only involves extra work, but the ties will lose additional lag or spike-holding capability from re-spiking.

For this reason it may be desirable to allow for the wear on the rail head when correcting gauge.

- This will leave the gauge wider than the 56-1/2 inches standard but still within the MARTA Track Safety Standards upon completion of the gauging operation, and will result in 56-1/2, inch gauge when the worn rail is replaced.

If the work is extensive enough to require realignment of most of the curve, many of the operations used in rail renewal can be used.

All rail, and plate-holding spikes or clips should be removed on one rail.

- Remember that the rail that will not be disturbed will be the reference to which the other rail is gauged. In a curve, this is the high rail, on tangent track this will be the line rail.

This means that the track will end up with the alignment of the undisturbed rail.

- Since the high rail usually has the better alignment, the low rail will usually be the rail to correct gauge with.

When there is an extensive amount of re-gauging to be done over a long stretch of track, like a long curve, many of the production operations used in rail renewal can be utilized.

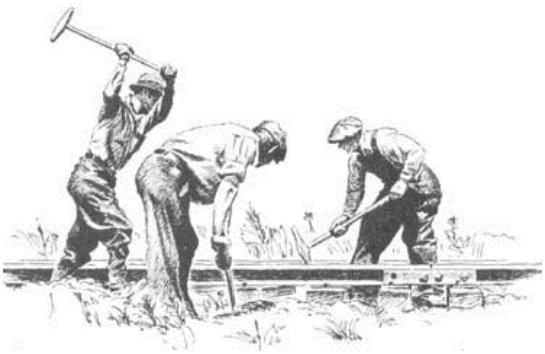
It is necessary to line the rail out of the way to provide clearance for the following operations.

- Except at the ends of the curve, the joint bars need not be removed.

After removal of the tie plates or pads, all spike holes or lag holes should be plugged. The ties should then be adzed as necessary to provide level seats for the tie plates or pads.

When the rail is placed in the tie plate or pads and the desired gauge is established, full spiking or lagging, and anchoring or clipping are carried out.

- This method lends itself to a high degree of mechanization.
- The amount of equipment actually used will, of course, depend on availability.



Spot Gauging in a Curve

If there are only a few critical spots in a curve that requires track gauge correction, a different method is much more appropriate.

- This method lends itself to the use of hand tools.

In spot gauging, the rail and pads or tie plates usually are not removed. If there is plate cutting, sufficient adzing is done adjacent to the gauge side of the tie plates with a track adz to permit the movement of the tie plates or pad to their proper position.

The spikes or lags are pulled and tie plugs inserted through the holes where the tie plates spikes or pad lags were located.

- The ends of the plugs should be punched completely flush with the tie plate or lag holes into the ties.
- Lining of the rail and the tie pads or plates to the correct gauge can then be completed.

Sometimes in locations where gauging is to be performed, there may be plate cutting present that has not resulted in improper canting of the rail.

- That is the amount of plate cutting on the ties is about the same on the gauge side edge of the tie plate as it is on the field side edge of the plate.

Equipment is available that provides for adzing a narrow strip cross the ties just inside the gauge side edge of the tie plates.

- If this equipment is used and all spike or pad holes are properly plugged, the gauge adjustment of tie plates or pad and rail can be accomplished without any future movement of the rail and tie plates or pads.

G. Re-established Track Gauge

It should be understood in any gauging operation that the ability to hold the newly established gauge depends on the soundness of the ties in the vicinity of the clips or lags.

There was probably some elongation of spike or lag holes before the work starts due to gradual spreading of the rails and pads or tie plates.

There may also be some weakening of the shoulder casting on concrete ties allowing for the casting to move laterally.

If the same tie pads or plate holes are used, the re-lagging or re-spiking will be done very close to the old spike or lag holes in the tie.

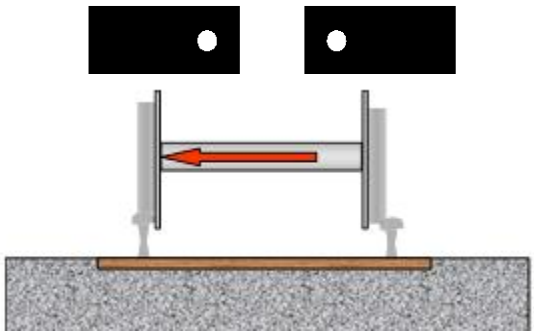
- For this reason, it is highly desirable to use tie plate holes for spiking that were not used previously. The wood in the vicinity of these new spike holes is more likely to hold spikes securely.
- Or use a tie pad that has the lag hole on the other side of the pad. Such as using a F-10/RO in place of a standard F-10 pad.

It is also good practice to renew deflective ties following a gauging operation.

The new ties will have much greater gauge-holding capability than the old plugged ties.

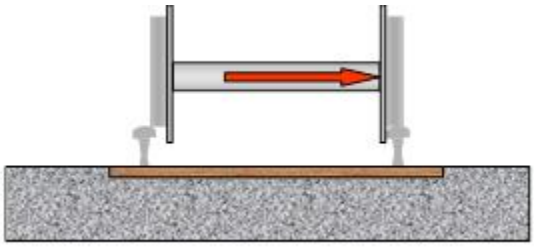
H. Effects of Truck Hunting on Tangents

Although the need for gauging is predominately on curves, the need for performing gauging work on tangents is increasing.



At higher train speeds, the trucks under many cars develop a tendency to rotate slightly, so the flange of one of the lead wheels bears tightly against the side of the railhead.

- It then reverses itself so the flange of the opposite wheel does the same with respect to the opposite rail.



This rotation can continually reverse itself at a fairly high frequency, and it is known as **truck hunting**.

Truck hunting in most cars begins at speeds of about 55 miles per hour. It can cause the cars to ride poorly, and sets up high stresses in both the cars of the train and the track.

The stresses imposed against the gauge side of the rail heads tend to create the usual undesirable conditions:

- Gauge widening
- Loosening of track fasteners
- Rail canting
- Wear on the gauge side of the rail head

The wider the gauge, the more severe truck hunting is at high train speeds.

- When maintaining, such high-speed tracks, close attention should be given to the development of conditions in the track structure that indicate a truck hunting problem is present.

Some are:

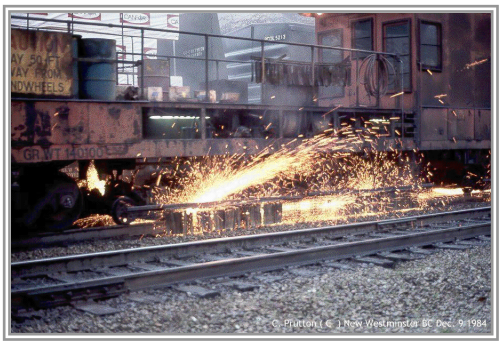
1. Wide gauge
2. Excessive wear on the gauge face of the rail
3. Wavy patterns on the rail head surface
4. Lateral pad movement
5. Stress cracks around the shoulder castings on concrete ties

I. Rail Surface Grinding

A maintenance procedure used by some railroads for correcting surface detects is the use of a rail surface grinding train. This equipment is capable of eliminating or reducing defects such as:

- Engine burns
- Corrugations
- Head checks
- Flaking
- Irregular welds

The grinding train passes over the track at slow speeds, grinding the rail heads to a smooth surface.



It is capable of removing about 0.006 inches of steel per pass. Several passes may be required to substantially reduce deep defects.

J. Rail Defect Detection

One of the major problems that transits and railroads have faced since the earliest days is the prevention of service failures in the track.

- As is the case with all modes of high-speed travel, failures of an essential component can have serious consequences.

With increased traffic at higher speed, and with heavier axle loads, rail inspection is more important today than it has ever been.

- Although the focus of the inspection seems like a fairly well-defined piece of steel, the testing variables present are significant and make the inspection process challenging.

Rail inspections were initially performed solely by visual means.

- Of course, visual inspections will only detect external defects and sometimes the subtle signs of large internal problems.

But when visual inspections are combined with ultrasonic defect detection, the complementary techniques lead to an improved and effective rail flaw detection package.

- The form of induction used today has been extended from rail bound to Hi-rail cars offering greater flexibility.

Rail is manufactured in different weights; there are different rail conditions (wear, corrosion etc.) present; there are a significant number of potential defects possible, and the task has to be performed with some speed to reliably inspect the thousands of miles of track stretching across the land.

The rails have evolved from cast iron plates to specially alloyed steels, which are rolled to a standard shape and specially heat-treated to obtain the desired properties.

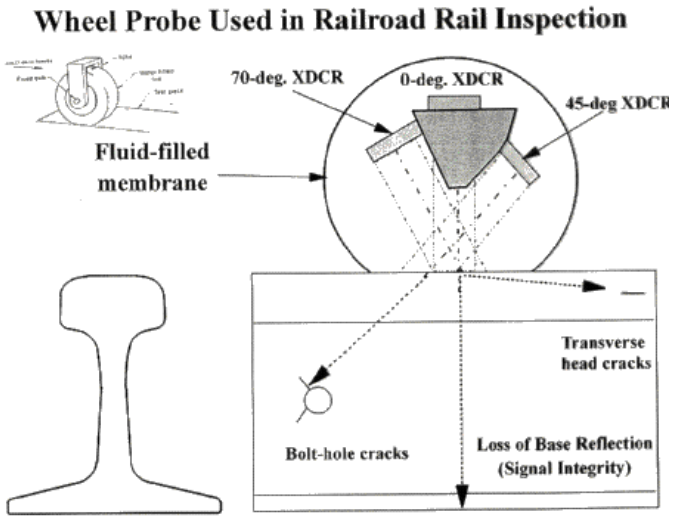
Present day steel rails are vastly superior to their predecessors in both strength and wear qualities, however defects still develop.

- The heavy loads and high speed of today's trains can cause rails to fail in service unless regular inspections are performed.

The need for a better inspection method became a high priority because of a derailment

The drawing below shows the basic operation of rail inspection using the induction method. Brushes are used to contact the rail and **inject** electrical current.

- The current creates a strong magnetic field in the rail.



Where there is a defect in the rail, the steel material will not support magnetic flux and some of the flux is forced out of the rail.

The sensing coil detects a change in the magnetic field and the defect indication is recorded on the strip chart or computers to record and evaluate the date.

High-frequency sound is transmitted into the metal rail and reflections from rail joints and surface conditions, as well as internal defects, are displayed on a screen or cause the computers to record and evaluate the date.
Both normal and angle beam techniques are used, as are both pulse-echo and pitch-catch techniques.

- The different transducer arrangements offer different inspection capabilities.

Manual contact testing is done to evaluate small sections of rail but the ultrasonic inspection has been automated to allow inspection of large amounts of rail, like the electromagnetic technique previously discussed.

The data from the inspection equipment is fed to the operator inside the car. Federal Railroad Administration (FRA) rules require that any indication considered suspect by the test equipment on the test car are hand verified immediately.

This leads to a stop-start test mode. When the operator sees something on the computer indicating a problem, he uses a buzzer signal system to tell the driver up front to stop.

The car then backs up to the point of examination where the operator gets out to hand test the rail with an ultrasonic test set mounted on the rear of the car.

- If a defect is confirmed, it is marked and a railroad work crew following the Sperry car will change the rail.
- If they can't get to it right away, the section of track is assigned a slow order (slower speed) until the crew can repair it.

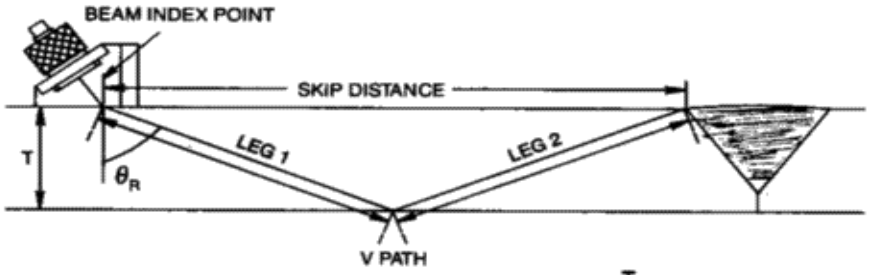
Ultrasonic flaw detection has long been the preferred method for non-destructive testing in welding applications.

- This safe, accurate and simple technique has pushed ultrasonics to the forefront of inspection technology.

Ultrasonic weld inspections are typically performed using a straight beam transducer in conjunction with an angle beam transducer and wedge.

- A straight beam transducer, producing a longitudinal wave at normal incidence into the test piece, is first used to locate any laminations in or near the heat-affected zone.

This is important, as an angle beam transducer may not be able to provide a return signal from a laminar flaw.



θ_R = Refracted Angle

T = Material Thickness

$$\text{Leg} = \frac{T}{\cos \theta_R}$$

$$\text{V-Path} = \frac{2T}{\cos \theta_R}$$

$$\text{Skip Distance} = 2T \times \tan \theta_R$$

The second step in the inspection involves using an angle beam transducer to inspect the actual weld.

- Angle beam transducers use the principles of refraction and mode conversion to produce refracted shear or longitudinal waves in the test material.

To determine the proper scanning area for the weld, the inspector must first calculate the location of the sound beam in the test material.

- Using the refracted angle, beam index point and material thickness, the V-path and skip distance of the sound beam is found.

Once they have been calculated, the inspector can identify the transducer locations on the surface of the material corresponding to the crown, sidewall, and root of the weld.

The Future of Rail Inspection

With increased rail traffic carrying heavier loads at higher speeds, a quicker more efficient way of inspecting railways is needed. Lasers inspect railway geometry, but one day they might be utilized as a form of non-contact evaluation of the rail.

- This most likely will be done with laser-optical transmitting transducers in ultrasonic testing.

Eliminating contact with the rail could one day allow high speed detection of flaws. Another need for the future is a complete rail inspection system. A step in this direction is deeper investigation of the rail by using low frequency eddy currents.

- Other advancements could include neural network analysis of signals to improve defect detection and identification and longitudinal guided ultrasonics.

Improved rail quality, composition, and joining techniques could lead to better wear characteristics and a longer lifespan of the rail. A safe and portable means of filmless radiography could assist with onsite defect evaluation.

- These are just a few advancements in the process of being developed for future use.

Exercise Questions

1. Name the three pairs of a rail.

2. Name the two sides of the rail.

3. What size rail is used at MARTA?

4. What is the standard length of rail?

5. What is the weight of a standard section of MARTA rail?

6. What information will be found in the rail brand?

7. MARTA uses two different types of rail, what are they?

8. Where will heat treated rail be used?

9. Where will control cooled rail be used?

10. Does MARTA use head hardened rail?

11. The greater the girder strength of the rail the better it can _____ the load over a greater number of ties.

12. What does CWR stand for?

13. Name the different types of rail joints used at MARTA.

14. All bent bolts must be _____.

15. What type of rail joints are recommended for concrete tie areas.

16. Is the diameter of the track bolts the same as the diameter as the bolt holes in the rail?

17. Name one problem caused by rail joints.

18. Describe distressing of CWR.

19. What is PRLT?

20. What is disturbed track?

21. Is the rail temperature and the ambient temperature the same?

22. Why is most rail replaced?

23. A section of rail is being laid, in that piece of rail is a torch cut bolt hole. What, if anything, must be done when this is found?

24. When taking the rail temperature, where should the rail thermometer be placed?

25. Scrape marks on the base of the rail made by Pandrol clips are an indication of what?

26. Ballast missing from the end of the ties is an indication of what?

27. Ballast bunched at the end of the ties is an indication of what?

28. Using the FRA Track Safety Standards book, what is the maximum allowable rail mismatch.

29. Using the MARTA Track inspection Manual, what is the shortest allowable length of rail allowed to be placed in the track?

30. When cutting rail for placement into the track, is it allowable to use a cutting torch?

31. What is the PRLT for MARTA?

Definitions and Terminology

Rail Definition of Terms

Base – the part of a rail lying below the web area also referred to as the foot or flange.

Bleeding – a reddish-brown streak indicating internal rusting. Noticeable in some rails containing vertical split head defects, generally under the ball of the rail.

Bonds – short wires used to bridge gaps in electrical circuits, usually at track circuit joints or between rails.

Break – a complete separation of one or more pieces of rail.

Broken Rail – a term commonly used to describe any rail that has been completely broken through the entire rail section.

Cant – the angle of an individual rail relative to vertical. Rail is canted by the inclination of the tie plate in order to match the conical wheel profile. Cant is usually expressed as a rate of inclination, such as 1 in 40, etc.

Cold work – plastic deformation of the rail material at low temperatures.

Continuous Welded Rail (CWR) – rail sections that are welded end to end into rail strings that result in a rail without rail joints; also referred to as welded rail or ribbon rail.

Corrugation – a series of wave-like variations of the rail head running surface, identified by an uneven head wear pattern. Short wave corrugation has a wavelength of 1–3 inches, intermediate wave corrugation has a wavelength of 3–24 inches, and long wave corrugation exceeds 24 inches in length. Short wave is more common on transit lines and high-speed lines, while all may be present within a heavy haul system.

Crack – a separation of metal extending partially, but not completely, through the rail section.

Defect – a term generally used to refer to an identifiable imperfection internal to the rail section or rail section geometrical surface.

Detected Defect – a defective rail detected by a rail flaw detection (RFD) vehicle or visual means by the operator of a RFD vehicle.

Fatigue – irreversible damage to a material caused by cyclic loading–normally leading to the formation of a crack.

Field side – the side of rail head away from wheel flange.

Flaking – usually refers to small pieces of parent rail material becoming detached from the rail running surface–a type of minute spalling sometimes associated with a faulty manufacturing process.

Flaw – a general term often associated with cracks originating from rail defects, but not always (e.g., it may relate to inclusions, segregation, weld discontinuities, or mechanical damage to a rail).

Fracture – usually the complete separation of one or more portions of the rail (also see “Break”).

Gauge Corner – the smaller upper rail head radius region that makes contact with the flange of a wheel.

Gauge Side – the side of rail closest to the wheel flange.

Gauge Line – the location on the gauge side of the rail head five-eighths inches below the rail tread that is used to establish track gauge.

Hair Line Crack – a fine and usually shallow surface crack.

Head Checks – transverse surface cracks on the gauge corner of rails, resulting from cold working of the rail surface. These are sometimes referred to as gauge cracks and controlled by preventative rail grinding.

Head-hardened Rail – a rail that has only the rail head hardened to provide a harder steel for locations where excessive loading forces may increase head wear, such as high side of a curve.

Heat – one batch of metal from a steelmaking furnace at the steel mill. All rails rolled from ingots or cast blocks from one heat.

Heat Treatment – the process of altering the properties of the rail material by a specific heating and cooling process. Heat-treated rail is good in locations that require a rail section of higher strength and durability.

High Carbon Rail – a rail with extra carbon added during the manufacturing process to increase hardness.

Inclusion – an impurity, normally an oxide or a sulfide. The inclusion can be generated by the steelmaking process or by in-track thermite welding processes.

Lip (Rail Lip) – a length of material, usually towards the lower edge of the rail head (This condition is typically found on the high side of curves) or at the surface edge of the rail in a rail joint, which has undergone severe plastic deformation to form a folded layer.

Nucleus – a term often used by metallurgists to refer to the origin or starting point of a defect.

Origin – the cause of a defect, the initial location of a defect, the point of initiation of a crack.

Percent Size – percentage of rail head cross-sectional area that is weakened by the defect (transverse defects only).

Pipe – term assigned to defects that originate from ingot casting procedures.

Progressive Fracture – term usually used to describe the gradual propagation of a crack over a period of time.

Rail Defect – may be a defect detected visually, ultrasonically, by other NDT methods, or may be exposed by an in-service rail failure that may render the rail unfit for normal operation.

Rail End – the part of jointed rail covered by the angle bar or a similar linear length in welded rail.

Rail Flaw – imperfections on the surface or interior of the rail section.

Rail Failure – a rail that is broken while in service. An internal defect may be present. However, a rail failure can result from conditions other than an internal defect (e.g., load impact, stress failure, etc.)

Rail Neutral Axis – the point in the rail web where internal pressure is compressive (pushing) above and tensile (pulling) below during vertical loading of the rail section.

Rail Neutral Temperature – the rail temperature at which there are no axial thermal forces in the rail section.

Rail Surface Irregularities – a rail surface irregularity is deformation or damage to the running surface of a rail, which can include the following: flaking, spalling, shelling, corrugation, localized rail head surface collapse, and crushed head and crack-out under the rail head.

Rail Wear – a reduction of the rail head as a result of abrasive action between the steel wheels on the steel rail.

Relayed Rail – worn, but still usable, rail taken from track and reused in another location (often referred to as secondhand or used rail).

Rolling Contact Fatigue – a form of rail fatigue damage originating primarily from cyclic loading in the wheel/rail interface zone.

Running Surface – a longitudinal band on the rail head where the wheels make contact with the rail–also referred to as the “bright band” or “rail tread.”

Rupture – a synonym for “fracture” or “break.

Seam – an internal rail longitudinal pocket that is inherent from the manufacturing process.

Section Modulus – the bending strength of a particular rail section.

Segregation – a result of an improper steel manufacturing process that can be identified by a separated or partially separated steel microstructure, mostly associated with the rail web.

Shatter Crack – discontinuous, internal cracks formed in steel due to stresses produced by localized transformation and decreased solubility of hydrogen during cooling after hot-working.

Shelling – a term associated with cracks originating from sub-surface defects or at the rail running surface that can result in considerable dislodgment of the rail parent metal.

Spalling – a term used to refer to the dislodged parent material area of the rail head that results from rolling contact fatigue.

Streak – a dark line seen on the running surface of the rail head.

Stress Relief – normally referred to as post-weld heat treatment.

Thermal Cracking – a rail defect identified as fine cracks across the rail head, caused by excessive heat generated at the wheel/rail interface.

Transposed Rail – rail that is removed from one side of the track to the other side, without turning the rail, so gauge and field sides are interchanged.

Tread – path of wheel contact with running surface of the rail.

Turned Rail – rail with some wear that has been removed, turned, and replaced in track, so gauge and field sides are interchanged.

Work-hardened Rail – rail that has a hardness greater than when manufactured, as a result of the cold working of the steel by cyclical traffic loading.

Metallurgical Terminology

Air Cooling – Cooling of the heated metal, intermediate in rapidity between slow furnace cooling and quenching, in which the metal is permitted to stand in the open air.

Alloy – (Met.) Metal prepared by adding other metals or non-metals to a basic metal to secure desirable properties.

Alloy Steel – Steel containing substantial quantities of elements other than carbon and the commonly accepted limited amounts of manganese, sulfur, silicon, and phosphorous. Addition of such alloying elements is usually for the purpose of increased hardness, strength, or chemical resistance. The metals most commonly used for forming alloy steels are nickel, chromium, silicon, manganese, tungsten, molybdenum, and vanadium. “Low alloy” steels are usually considered to be those containing a total of less than 5 percent of such added constituents.

Basic Oxygen Process – A steelmaking process wherein oxygen of the highest purity is blown onto the surface of a bath of molten iron contained in a basic lined and ladle-shaped vessel. The melting cycle duration is extremely short with quality comparable to open hearth steel.

Bessemer Process – A steelmaking process in which air is blown through the molten iron so that the impurities are thus removed by oxidation.

Bloom – (Slab, Billet, Sheet-Bar.) Semi-finished products, hot rolled from ingots. The chief differences are in their cross sectional areas in ratio of width to thickness, and in their intended use.

Blooming-Mill – A mill used to reduce ingots to blooms, billets, slabs, sheet-bar, etc. (See “Semi-Finished Steel.”)

Break Test – (For tempered steel) A method of testing hardened and tempered high-carbon spring steel strip wherein the specimen is held and bent across the grain in a vice-like calibrated testing machine. Pressure is applied until the metal fractures, at which point a reading is taken and compared with a standard chart of brake limitations for various thickness ranges. (See “Bend Test.”)

Brinell Hardness (Test) – A common standard method of measuring the hardness of certain metals. The smooth surface of the metal is subjected to indentation by a hardened steel ball under pressure or load. The diameter of the resultant indentation, in the metal surface, is measured by a special microscope and the Brinell hardness value read from a chart or calculated formula.

Brittleness – A tendency to fracture without appreciable deformation.

Butt Welding – Joining two edges or ends by placing one against the other and welding them.

Carbon Steel – Common or ordinary steel as contrasted with special or alloy steels, which contain other alloying metals in addition to the usual constituents of steel in their common percentages.

Continuous Casting – A casting technique in which the ingot is continuously solidified while it is being poured and the length is not determined by mold dimensions.

Cooling Stresses – Stresses develop by uneven contraction or external constraint of metal during cooling; also those stresses resulting from localized plastic deformation during cooling and retained.

Corrosion – Gradual chemical or electrochemical attack on a metal by atmosphere, moisture, or other agents.

Deburring – A method whereby the raw slit edge of metal is removed by rolling or filing.

Degassing Process – (In steelmaking) Removing gases from the molten metal by means of a vacuum process in combination with mechanical action.

Ductility – The property of metals that enables them to be mechanically deformed when cold, without fracture. In steel, ductility is usually measured by elongation and reduction of area as determined in a tensile test.

Fatigue – The phenomenon leading to fracture under repeated or fluctuating stress. Fatigue fractures are progressive, beginning as minute cracks, and grow under the action of fluctuating stress.

Finished Steel – Steel that is ready for the market without further work or treatment. Blooms, billets, slabs, sheet bars, and wire rods are termed “semi-finished.”

Fracture Test – Nicking and breaking a bar by means of sudden impact, to enable macroscopic study of the fracture.

Hardening – Any process that increases the hardness of a metal. Usually heating and quenching certain iron base alloys from a temperature either within or above the critical temperature range.

Hardness – Degree to which a metal will resist cutting, abrasion, penetration, bending, and stretching. The indicated hardness of metals will differ somewhat with the specific apparatus measuring hardness.

Heat Treatment – Altering the properties of a metal by subjecting it to a sequence of temperature changes–time of retention at specific temperature and rate of cooling therefore being as important as the temperature itself. Heat treatment usually markedly affects strength, hardness, ductility, malleability, and similar properties of both metals and their alloys.

Inclusion – Particles of impurities (usually oxides, sulfides, silicates, etc.) that are held mechanically or are formed during the solidification of or by subsequent reaction within the solid metal.

Ingot – A casting for subsequent rolling or forging.

Open-Hearth Process – Process of making steel by heating the metal in the hearth of a regenerative furnace. In the basic open-hearth steel process, the lining of the hearth is basic usually magnetite; whereas, in the acid open-hearth steel process, an acid material, silica, is used as the furnace lining.

Oxidation – The addition of oxygen to a compound. Exposure to atmosphere sometimes results in oxidation of the exposed surface, hence a staining or discoloration. This effect is increased with temperature increase.

Plastic Deformation – Permanent distortion of a material under the action of applied stresses.

Residual Stress – Macroscopic stresses that are set up within a metal as the result of non-uniform plastic deformation. This deformation may be caused by cold working or by drastic gradients of temperature from quenching or welding.

Rolling Mills – Equipment used for rolling down metal to a smaller size or to a given shape, employing sets of rollers that determine or fashion the product into numerous intermediate and final shapes, e.g., blooms, slabs, rails, bars, rods, sections, plates, sheets, and strips.

Seam – (A defect) On the surface of metal, a crack that has been closed but not welded; usually produced by some defect either in casting or in working, such as blowholes that have become oxidized or folds and laps that have been formed during working. Similar to cold shut and laminations.

Segregation – In an alloy, concentration of carbon or alloying elements at specific regions, usually as a result of the primary crystallization of one phase with the subsequent concentration of other elements in the remaining liquid.

Slag – A product resulting from the action of a flux on the nonmetallic constituents of a processed ore, or on the oxidized metallic constituents that are undesirable. Usually slags consist of combinations of acid oxides with basic oxides, and neutral oxides are added to aid fusibility.

Sliver – (a defect) Loose metal piece rolled down onto the surface of the metal during the rolling operations.

Stress – Deforming force to which a body is subjected or the resistance that the body offers to deformation by the force.

Structure – The arrangement of parts, in crystals, especially the shape and dimension of the unit cell, and the number, kinds and positions of the atoms within it.

Tensile Strength – (Also called ultimate strength) Breaking strength of a material when subjected to a tensile (stretching) force, usually measured by placing a standard test piece in the jaws of a tensile machine, gradually separating the jaws, and measuring the stretching force necessary to break the test piece. Tensile strength is commonly expressed as pounds (or tons) per square inch of original cross section.

Toughness – Property of resisting fracture or distortion, usually measured by impact test, high-impact values, indicating high toughness.

Work Hardening – Increase in resistance to deformation (i.e., in hardness) produced by cold working.