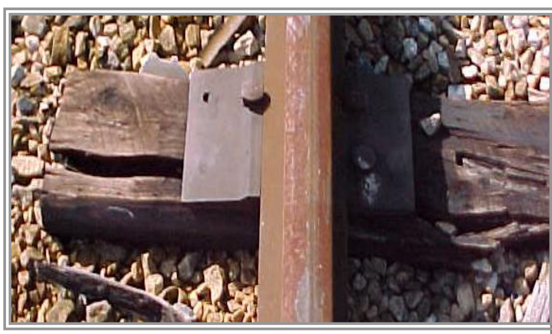
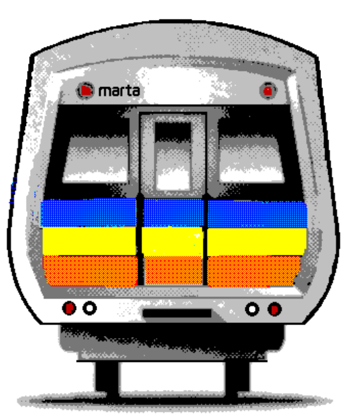
Track Inspection Training



Metropolitan Atlanta Rapid Transit Authority

Track Inspection Training



Metropolitan Atlanta Rapid Transit Authority
Department of Technical Training
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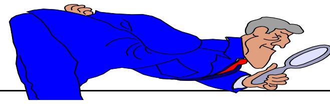
Track Inspection Training

Introduction

Section 1



Track Inspection

A variety of conditions can cause a track to be defective. Although some defects occur suddenly, it is more common for defects to develop gradually.

- Some defects can be traced to poor workmanship in the construction or maintenance of a track, or to defects in the manufacture of materials.
- Other defects can develop over a period of time, even if the track is not used.

Certain forms of deterioration are the result of weathering and other natural forces.

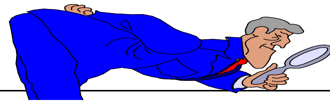
- But the most significant cause of track structure deterioration is rail traffic.

The more severe the rail traffic in terms of total tonnage, individual wheel loads, and train speed, the greater the rate of deterioration will be.

All tracks have less than perfect conditions.

- This requires correcting each undesirable condition before it deteriorates beyond its accepted limit.

These accepted limits are specified by MARTA in the interest of sound economic practice. In the absence of any standard of this type, the maximum limit is the limit of safety, as specified by MARTA or the Federal Railroad Administration (FRA) Track Safety Standards.



Inspection Duties

Some Track personnel have duties that are primarily related to maintenance of track.

- They may be responsible for some specialized activity, such as rail laying, tie installation or pad replacement.

Track inspection is not considered to be part of their duties. Nevertheless, in the course of their work, they will most certainly observe track defects that merit prompt attention.

- While these Track personnel are not part of the basic track inspection organization, they can serve as an important supplement to it.

Every track person should understand that it is part of their responsibility to correct any critical condition that is found, or to take immediate protective action.

- Track personnel who are observant of potentially hazardous conditions will strengthen any track inspection program.

Some Track Personnel have combined inspection and maintenance duties. These Track Personnel are responsible for knowing the condition of tracks within their section of track territory, for maintaining those tracks in a safe condition, and for taking protective action when they do not have enough resources to correct a potentially hazardous condition.

Still other Track Personnel have responsibilities that consist primarily of track inspection.

- They may or may not have some additional resources under their jurisdiction to make limited repairs.

Many of the conditions that they locate will have to be repaired by other personnel.

- These Track Personnel have the advantage of having a mental picture of the conditions they locate.

The employee that assigns personnel to make repairs and the employee in charge of carrying out the work do not have this advantage.

They must rely upon the information they receive from the person who conducts the inspections. The manner in which the track inspection reports are made is extremely important in these circumstances.

Inspection Program

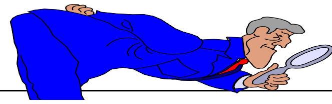
As a full time track inspector, you must have a schedule that will provide for the inspection of all track and other facilities that, at the least, conforms to the frequency requirements specified by MARTA.

This schedule must be practical. Due consideration must be given to the on track time available for an inspection.

A well-trained track inspector learns to observe many signs that indicate a defect.

Time must also be allotted for the monthly inspection of switches, turnouts, and track crossings.

- This might be accomplished by inspecting a few of these facilities during each inspection, or by devoting a few days a month exclusively to this work or by some other arrangement.



In addition to regular track inspections, special inspections must be made during heat or extreme rail temperatures. These inspections will prove to be very instrumental in the prevention of track buckling and CWR maintenance in general.

During these special inspections, the track inspector should look for rail canting; rail riding up in the tie pads; scrape marks on the base of the rail caused by longitudinal movement. Longitudinal movement of switch point to stock rail, kinked rail, rail anchors that are missing, worn or not snug to the tie, skewed ties, poor alignment of track, changes in track alignment, irregular gauge and churned or displaced ballast. Along with other areas that need to be inspected.

Proper record keeping, good maintenance practices good inspections and appropriate follow-up action will reduce the chances and effects of buckled track.

Detecting Problems

In order for a condition to be corrected, its existence must be brought to the attention of someone who has authority to take action.

- Many serious track conditions have been detected by someone who happens to casually notice them.

A system of regular track inspections is integral to any organization that is created for the purpose of maintaining tracks. These inspections have several purposes:

1. To take immediate protective or corrective action if any hazardous conditions are found.
2. To identify any conditions which have deteriorated to a point that justifies prompt corrective measures (usually spot work).
3. To determine needs for programmed maintenance operations.

Although most track conditions that are termed defects occur after a period of gradual deterioration, some conditions become visible to normal inspection suddenly.

- There are times when they create a serious hazard as soon as they become visible.
- This creates a need for inspecting track at fairly frequent intervals.

There are so many different things to look for, that a track inspector must take their time to completely inspect their assigned section of track.

Therefor it is necessary to restrict the day's track inspection work to a very limited amount of track, in order to consider the track completely inspected.

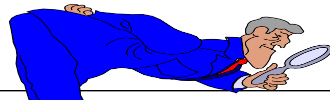
The need for frequent inspections to promptly identify hazardous conditions conflicts with the concept of thorough track inspection. A sound inspection program must balance these requirements.

Severity Estimators

Severity Estimators is a rating system designed to enable the Track Walker to effectively communicate track conditions. Definitions and examples are as follows:

Green

Track observations, conditions or defects that are reported for the purpose of monitoring. Such conditions do not affect system safety, ride quality or personal safety. This rating should be used to identify conditions that may eventually develop into a defect requiring corrective action.



Examples:

1. Minor engine burns in the rail head
2. Lubricator carry curves that are in acceptable condition (having grease on the gauge corner of the rail)
3. (1) tunnel light out

Yellow

Track conditions or defects that require corrective action but do not affect system or personal safety. These defects will be monitored, prioritized for repair and addressed as resources and schedules permit.

Examples:

1. Lubricator carry curves that are dry (no visible grease and no rail shavings visible)
2. Minor overflow or hairline crack in frog point
3. Minor rail-end batter
4. Track Geometry deviations as defined in MARTA's Track Inspection Procedures

` **Red**

Track conditions or defects that require immediate train protection and or immediate corrective action. Train protection includes slow orders, visually flagging trains over condition or removing track from service.

Examples:

1. Defective, damaged or broken rail or track component
2. Cracked or broken frog point
3. Broken Shoulder or Heelblock bolt
4. Track Geometry deviations as defined in MARTA's Track Inspection Procedures.

DOCUMENTATION

Track and Switch Inspection Reports

Service Requests/Defects shall be entered into the CMMS via the Mobile focus or FA Suite applications.

An automatically updated track Inspection Report, will be carried by each Track Walker to prevent duplicate entries.

The updated inspection report and subsequent work order will be printed from the CMMS signed by the Track Walkers and maintained for managerial and outside review.

Reports will be reviewed by the Track Inspection Supervisory personnel and Track Inspection Planner for scheduling of work.

Items of significance or needing attention should be brought to the immediate attention of the Track Inspection supervisory Personnel.

Marked Measurements

Marked Measurements will be entered into the CMMS via the test result function of FA Suite or Mobile Focus. The test type ID is “TS4-SW-MEASURE”.

This inspection will include comments, gauge, crosslevel, flangeway, guard face and guard check readings. This report will be printed, signed by the inspectors, attached to the corresponding work order and filed with the Track Inspection Foreman.

Rail Lubricator Inspection Report

Rail Lubricator PM work orders will be completed daily in the MMS and filed with the Track Inspection Supervisory personnel for each rail lubricator that is inspected.

Track Maintenance Daily Summary Report

All work performed on mainline and secondary tracks will be reported on the Track Maintenance Daily Summary Report.

This report will be shared daily with the Track Walkers prior to the daily track inspection. All maintenance work will be recorded and tracked in FA Suite for reporting purposes

Drawings, Manuals, and Specifications

All pertinent drawings, manuals and specifications are available for review and consultation at the Track and Structures Maintenance Office.

INSPECTOR REQUIREMENTS

Qualifications

Must have completed high school and received a diploma or GED equivalent.

Must have good English language oral and written skills.

Must have a minimum of three (3) years experience within MARTA's Track Maintenance and Structures Division or equivalent. Also he/she must demonstrate their knowledge in a structured interview given by MARTA Supervisory Personnel. This interview shall consist of two (2) sections, a written and a hands-on/field evaluation. Candidates must achieve a score of at least an 80% average in order to be considered for a Track Walker position.

Be knowledgeable in MARTA’s track standards and inspection procedures.

The Track Walker will be required to take a re-certification exam at least twice yearly.

At this time he/she must display their knowledge and achieve a score of at least 80%.

If the individual does not achieve a passing score of at least 80%, the Track Walker will be placed on 3 months’ probation. During the probation, the Track Walker will be allowed to inspect track only with a certified Track Walker. The Track Walker may re-test any time during this probation period but must obtain certification before the end of the 3 month period which begins with the date of the first test.

If the individual does not achieve a passing score of at least 80% on the exam:

· The Training Instructor will contact the individuals management staff to provide details of examination results

· The employee will be instructed to perform self-study

· The management staff will consult with the Track Walker and schedule the first re-test

· The re-test scoring will be evaluated accordingly

If the individual fails the first re-test:

· The Training Instructor will contact the individuals management staff to provide details of examination results

· The employee will be instructed to perform self-study

· The supervisor will have ten (10) days to consult with the Track Walker and schedule a second re-test.

· The re-test scoring will be evaluated accordingly with the results sent to the individuals management.

If the individual fails the second re-test:

· Track & Structures management will notify the individual of their disqualification from current job position.

· If disqualified, the individual will have fourteen (14) days following notification to occupy another position within Track & Structures or the Authority, (other than Track Walker) as seniority and qualifications allow.

The employee will **<u>not</u>** be eligible to return to this craft or test for the position of Track Walker within 12 months from the disqualification date pursuant to paragraph 228 of the current labor agreement.

Inspector Duties

The primary duties of the Track Walker are as follows:

Make a thorough inspection of the assigned territory at the designated time interval to insure that the track, and all pertinent structures and right of way are in a safe and operable condition. If any unsafe conditions are found, based on the information in this procedure, the Track Walker shall take steps at once to protect approaching trains. The Track Walker shall notify the Rail Control Center and the Track Inspection Foreman. It is the responsibility of a qualified Track Walker to take the appropriate action, based on their inspection of the track. This includes immediate correction of the problem, reporting of the problem in the proper manner for verification and follow-up, or immediate protective action which includes:

<u>Slow Orders</u>

1. **Slow order. (according to preset speed restrictions or adjusted track speed to the class of track for which the track is rated.)**
2. **Visual supervision of the train operation (flagging) through the affected area.**
3. **Taking the track out of service.**

Keep themselves informed of work performed in their assigned territory by MARTA crews or contract personnel to insure no work is done that will interfere with safe passage of trains.

Give special attention to places where obstructions are likely to occur, examine slopes for the possibility of slides and falling rock.

Examine mainline track and components including but not limited to, turnout frogs, crossing frogs, joint bars and bolts, bonded, insulated and standard bonded joints, rail track surface, alignment and gauge, switch rods, tie and ballast conditions, rail lubricators, hi-rail accesses, rail anchors, direct fixation fasteners, direct fixation concrete and anchors, contact rail, fencing, vegetation conditions, structures, etc., looking for defects or breaks and other conditions that require corrective maintenance.

Any obstruction to the track must be reported immediately to the Rail Services Control Center and appropriate steps taken to protect approaching trains.

Note any potential areas which would allow for unauthorized persons or wildlife to enter the property. Any unauthorized personnel on the wayside should be reported immediately to the Rail Services Control Center.

Observe conditions of the contact rail (3rd rail), feeder and return cables, Train Control, Communication and all wayside equipment and report any conditions needing attention to the Track Inspection Supervisory personnel.

Additional Duties

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Update the CMMS Service Request/Defect Function during and after each inspection for review by the Inspection Foreman.

Escort contractors or other personnel whose work requires wayside access.

Perform corrective maintenance of track when applicable. (This includes but is not limited to, tightening of gauge rods, rail clips, adjustment of 3rd rail anchors, removal of vegetation, etc.)

· Conduct special inspections of project work.

· Perform other miscellaneous duties as assigned

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Observe conditions of the contact rail (3rd rail), feeder and return cables, Train Control, Communication and all wayside equipment and report any conditions needing attention to the Track Inspection Supervisory personnel.

For example:

Time should be budgeted further to cover other necessary inspection work.

- In addition to the monthly switch inspection, there will be yard and sidetracks to be inspected on a monthly schedule.

Perhaps, check a couple of curves each trip with a gauge inspection.

- Keep records of when each curve is checked to make sure none are missed.
- When this is completed, then make track cross-level and elevation inspections on a similar basis.
- This is particularly necessary on D.F. Track

As previously stated, most track defects develop gradually.

The inspector who uses a system that provides for detailed coverage of all necessary areas will be aware of developing conditions. They will seldom be surprised by unexpected critical defects.

The matter of developing an inspection plan should not be governed by inflexible rules. The plan must be tailored to each segment of the system.

- The track in which CWR is installed may not need as much attention to rail joints as jointed rail.

The line with a great deal of curvature will require more attention to gauge and curve rail head wear than the territory which has mostly tangent track. The track that has marginal tie conditions needs a different emphasis in the inspection plan than the track with a reputation for unstable roadbed.

Rail

Many rail defects can only be detected by a rail flaw detector car (Sperry car) or other specialized detection equipment.

- Even so, some defects can be identified by visual inspections, as well as conditions caused by wear or damage.

A track inspector should always be familiar with the general state of rail wear within their territory.

- Except for rail joint conditions, rail wear will occur mostly on curves.

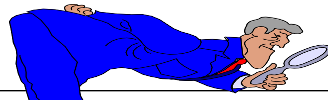
As rail begins to wear on a curve, flange wear will develop on the gauge side of the head of the high rail.

- Lipping from rail flow may begin to develop.
- This is usually most severe on the field side of the low railhead, but may also appear on the gauge side of the low rail or the field side of the high rail.

The inspector's first concern, as wear develops, is to determine with the help of their Inspection Foreman the point at which the rails are ready for transposing.

One of the prime considerations will be to transpose the rails before any appreciable rail flow forms on the field side of the low rail.

- This becomes the gauge side of the high rail after transposing.
- In this location, wheel flanges can cause severe chipping of the gauge comer of the railhead, if a lip is present.



In later stages of rail wear on curves, the extent of flange cutting of the high rail becomes a major concern.

- One reason for this is that it may be contributing to a critical gauge condition.

Flange wear also may progress to a point where the strength of the railhead becomes endangered. The wheel loads are gradually transferred to the railhead at points further toward the field side. This causes a tendency to bend the railhead and may result in a head and web separation.

Railhead lip is caused by the flow of steel under the rolling load of wheels.

- This is accompanied by a flattening or lowering of the railhead. Railhead flattening can become severe enough to be a cause of concern.
- It can result not only in a weakening of the railhead, but also in wheel flanges striking the tops of joint bars.

This is just an introduction to the track inspection training. Each of the track components will be dealt with separately. Each have their own rules, requirements and regulations. These will be included with each section.

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Technical Training

Track & Structures

Track Inspection Training

Table of Content & Course Objectives

Section 2

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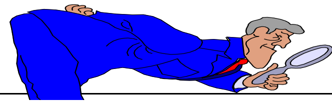


Introduction

Track Inspection training provides a review of MARTA and F.R.A. track inspection standards. At the end of this course, students will be able to properly inspect MARTA track, determine severity of defects and determined correct course of action to ensure safe operations.

A. Requirements

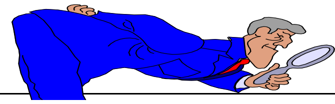
Test scores must be 80% or higher on all written and field evaluations. Only one retest will be allowed on any written or field evaluation without additional training. All MARTA Track Inspection personnel must demonstrate knowledge of MARTA and F.R.A. track inspection criteria.

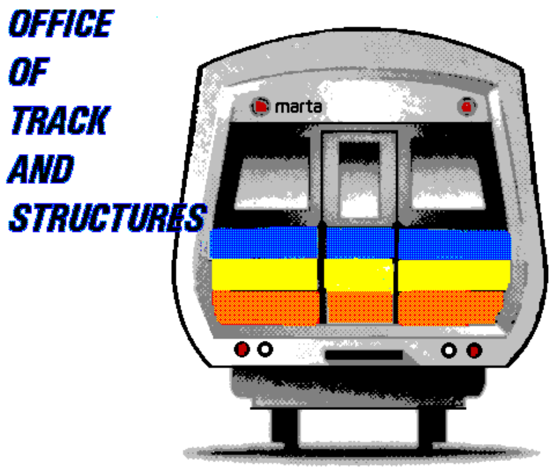
Each student will be asked to complete a class/instructor evaluation at the end of the class.

B. Learning Objectives

Class Objective

Demonstrate the ability to correctly inspect MARTA track in accordance with MARTA and F.R.A. track safety standards.





Section Objectives

Roadbed & Ballast: Demonstrate the understanding of the way the roadbed and ballast work in conjunction to distribute the loads placed on the track.

Crossties: Demonstrate the ability to correctly grade concrete and wooden crossties. Demonstrate an understanding of MARTA and F.R.A. track safety standards for crossties and crosstie responsibility in its ability to perform its three basic functions. Demonstrate the understanding of the way the crossties distribute the loads placed on the track

Rail: Demonstrate the ability to recognize compressive and tensile forces in C.W.R. Demonstrate the ability to measure curve worn rail and determine if it meets MARTA or F.R.A. standards. Demonstrate the ability to recognize lateral, vertical and longitudinal forces placed on the track by train loads and thermal dynamics. Demonstrate the understanding of the way the rail distributes the loads placed on the track

Rail Joints: Demonstrate the ability to recognize the different types of rail joints used at MARTA and what function each perform. Demonstrate the ability to recognize rail joint defects and demonstrate the ability to show the effects that rail joints have on other track components.

Rail Defects: Demonstrate ability to identify different types of rail defects and their causes. Demonstrate the ability to correctly use the Remedial Action Table found in the F.R.A. track safety standards to determine the correct course of action to ensure safe train operations.

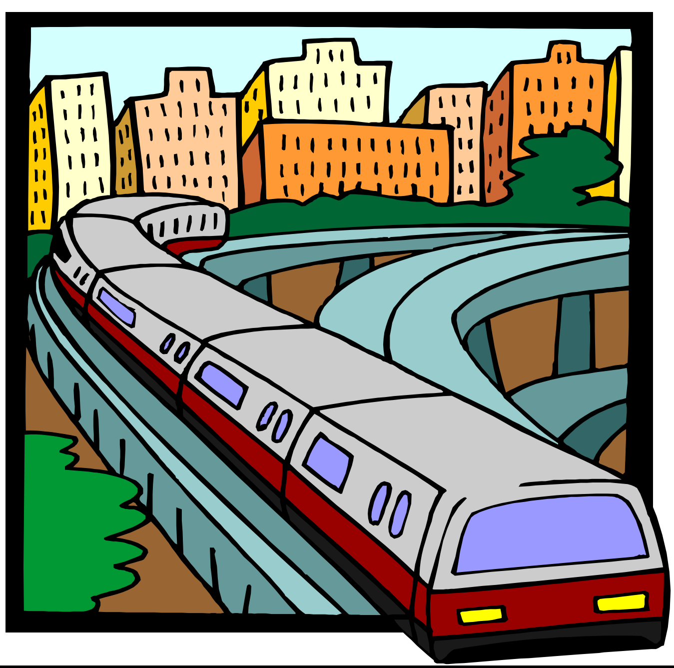
Turnouts & Crossovers: Demonstrate ability to take and record marked measurements, frog and switch point measurements. Demonstrate ability to recognize switch defects and estimate their severity and determine the proper action to ensure train safety. Demonstrate ability to measure the actual lead and off-set readings for the turnout. Demonstrate ability to measure line and surface problems within a turnout.

Track Charts: Demonstrate the ability to locate all curve locations and curve points found in a simple, compound and reverse curve. Demonstrate the ability to determine changes in elevation in the spirals of a curve. Demonstrate the ability to find wayside any and all track components listed in the track charts.

Track Surface: Demonstrate the ability to measure track surface defects. Demonstrate the ability to measure warp and twist and have the ability to describe possible effects of both. Demonstrate the ability to measure track run-off and how to determine if it meets MARTA and F.R.A. track standards. Demonstrate the ability to recognize surface defects and determine if they are within MARTA and F.R.A. track safety standards and what action if any is required for that surface defect. Demonstrate the ability to determine the cause of the surface defect.

Track Alignment: Demonstrate ability to find, in the Track Charts, all curve related data and how it relates to track inspection. Demonstrate the ability to recognize alignment defects and determine if they are within MARTA and F.R.A. track safety standards and what action if any is required for that alignment defect. Demonstrate ability to find all curve points for simple, compound and reverse curves. Demonstrate ability to determine line, gauge and grade rails on tangent and curved track.

Stringlining Track: Demonstrate the ability to find all necessary curve points in order to mark stringline stations. Demonstrate the ability to measure and mark all necessary stringline stations. Demonstrate the ability to fill out a Stringline Data Sheet and then to take stringline readings correctly. Demonstrate the ability to calculate simple stringline throws in order to return the track to proper alignment.



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Roadbed

Section 3

ROADBED

When a new track is to be constructed, a roadway for the track must be graded. Upon completion of the grading, the surface, which is provided for placing a track or tracks on, is known as the sub-grade.

- In most new construction**, sub-ballast** will be placed above the **sub-grade,** before placing the **ballast**.

A. Roadbed and Roadway

The material below the sub-grade, which supports the track and loads placed upon the track, is known as the **roadbed**.

- Frequently, people will refer to the roadbed as the sub-grade.

In this course, the two terms will not be so used. Sub-grade, will mean only the top surface of the roadbed which is the definition used by the **American Railway Engineering Association. (AREA)**

- The roadbed is not to be confused with the **roadway.**
- Roadway is a more inclusive term.

The roadway includes the roadbed, but it also includes the other essential parts of the right-of-way. Roadway includes ditches and drainage systems, cuts, tunnels and other necessary appurtenances, such as fences and signs.

Consider how it is related to subsequent maintenance. Over a period of time, the track will probably undergo a series of raises.

This will increase the width of the ballast section. If the 2:1 slope of the ballast shoulder is maintained, a 3-inch increase of ballast depth will extend the ballast shoulder outward 6-inches. (Again a 2 to 1 ratio)

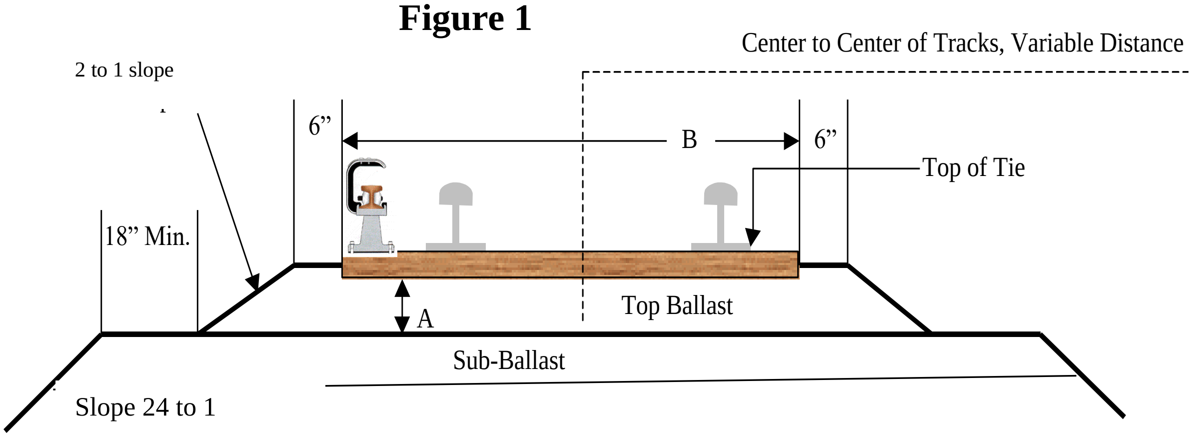
- Also, over a period of time, the edge of the roadbed or sub-ballast will tend to round off. This further reduces the margin available to retain the ballast shoulder.

If the roadbed is on a fill, there will probably be locations where erosion develops. Such erosion may further reduce the width of the roadbed at the sub-grade.

It can be seen that the 18-inch extension of the sub-grade beyond the toe of the ballast is a safety factor that will be reduced and perhaps eliminated over a period of years.

AREA ballast sections, single and multiple tracks on tangent.

Figure 1



Ballast Section Number 1

Transmitting Loads

First, consider the requirement that ballast transmits the loads, which are placed on it to the sub-grade.

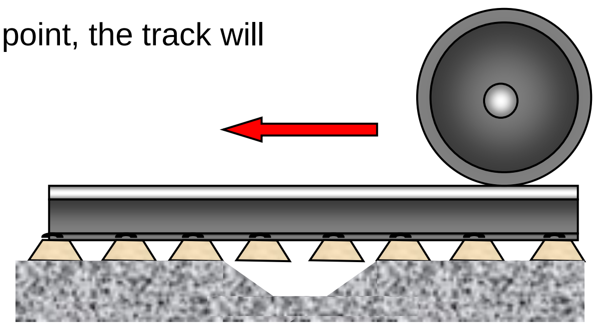
There is no question that the ballast will transmit (or send on) the loads to the material under the ballast, if the ballast is supporting the ties.

Suppose that in a small area, covering a few ties, the ballast is not supporting the track.

- Perhaps, these ties are hanging loose when there is no train on the track.

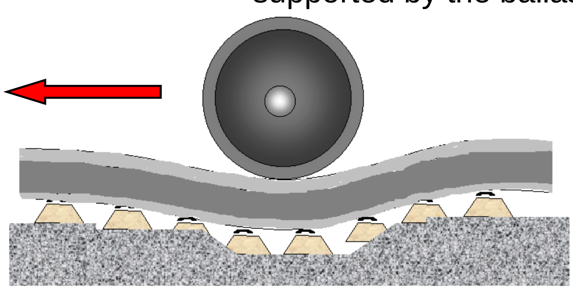
If a heavy wheel load is placed over this point, the track will depressed.

- This is known as pumping.



The bottom of the ties establishes contact with the ballast.

- However, because of the stiffness of the rail, most of the load is being transmitted through nearby ties that were firmly supported by the ballast.



In this case, the ballast under the loose ties is not carrying its share of the loads.

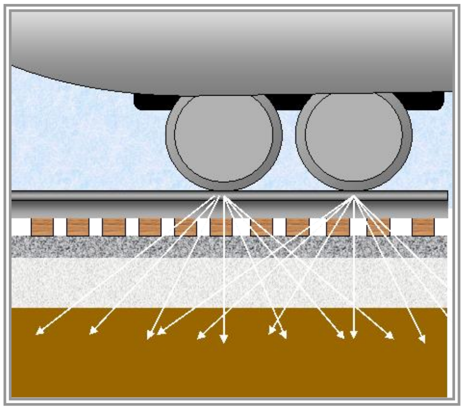
In the language "It is not properly transmitting the load."

The corrective action is to place ballast under the loose ties, this is called tamping ties, so that the loads will be transmitted to the sub-grade as intended.

Distributing Loads

It has been previously shown that depth of ballast is the key to distribution of loads.

- Within practical limits, the deeper the ballast, the more the loads which are imposed at the bottom of the tie will be spread out where the ballast meets the sub-grade.



The standards do not indicate how much depth of ballast is required to distribute the loads.

- This can vary substantially.

One thing, which will affect the amount of ballast required, is the nature of the traffic. A track, which carries only a small amount of traffic may be adequately ballasted with 6-inches of ballast below the bottom of ties.

- Tracks with a high density of traffic, predominately heavy wheel loads or **higher speeds**, may need considerably more depth of ballast to adequately distribute the loads.

The sub-grade material may also be a factor in the depth of ballast required. Some soils cannot support as heavy a load as other types of soil.

The weaker soils will require the loads to be spread out over larger areas, if they are to adequately support them.

Some soils will require better distribution of the load in areas of heavy rainfall, than they will in normally dry regions.

In most situations, if a problem of inadequate ballast depth exists, it can be corrected without much difficulty. Additional ballast is unloaded.

C. Restraint of Track

The second requirement of ballast standard is that the ballast will restrain the track laterally, longitudinally, and vertically under dynamic loads imposed by railroad rolling equipment (trains) and thermal stress, exerted by the rails (expansion or contraction due to weather conditions).

- In most ways, the ability to restrain the track laterally and longitudinally are inter-related.
- Most lateral displacement results from failure to restrain the track longitudinally. It has been shown that rail tends to creep longitudinally.
- The main reasons are the influence of rail traffic and temperature changes within the rails.

Rail Movement

If rail is permitted to move longitudinally, at some point in the track and at some period of time, higher than normal compressive stresses will develop in the rails. If these compressive stresses become large enough, the track will begin to move laterally, or vertically, or buckle.

- This can be extremely dangerous.
- It can happen quite suddenly, in front of or even under a moving train.
- A serious derailment may result.

Such hazards can be avoided if the rails are adjusted properly and restrained from moving longitudinally. This restraint must be provided by other parts of the track structure.

Pandrol Clips or Rail Anchors are applied to the rail. Rail anchors, if properly applied, will keep the rails in the same position relative to the anchored ties. (Yard tracks)

If the ties, to which anchors are applied, are not adequately restrained, the rail will still be free to move longitudinally. It is necessary that these ties be restrained from creeping.

Pandrol clips act as their own rail anchors, thus preventing lateral, vertical and longitudinal movement of the track.

The ties must be restrained by the ballast.

- The amount of restraint provided by the ballast can be very small or it can be considerable.

There are several things, which determine how much restraint should be provided.

Amount of Ballast

The amount of ballast in the cribs between ties is one of the more important factors in the restraint of ties.

- You should know what your standards are for the amount of ballast in the track structure.

Many transits and railroads require that ballast cribs be full to the top of the ties, at least for welded rail.

- Such standards should never be ignored, even for short periods.
- If the standard is not met, temporary operation of trains may be justified, but at reduced speed.

Consideration must be given to existing and probable rail temperatures. Any such expediency should only be for short periods, until adequate ballast is provided.

- Slow speed train operation may minimize immediate danger.

It must be recognized that insufficient ballast may permit some longitudinal movement. A later application of ballast will not correct this.

- This could combine with some subsequent condition, such as a high rail temperature, to cause excessive compression.

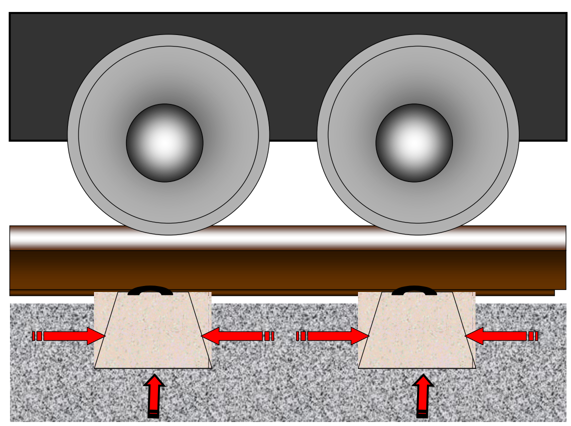
Bond between the tie and the ballast

There is the importance of the bond between the bottoms, the sides and the ends of the ties and the ballast, in providing longitudinal and lateral support.

It must be recognized that this bond is at a minimum under certain conditions.

These include:

- Track which has recently been raised or lined.
- Track in which tie renewals have recently been made.
- The installation of new track.



This bond will be restored gradually, under traffic. Until this happens, this lessened capability for restraint from this source must be recognized. This makes other sources of restraint, such as full tie cribs, of particular importance at this time.

Type of ballast

The amount of restraint, which can be expected from the ballast also depends on the type of ballast.

- Ballast with sharp, angular edges, such as crushed rock, or crushed slag are superior in this respect.
- Types of ballast, in which the particles do not interlock as well, such as gravel, have less potential for restraint.

Gravel can be quite adequate for light to moderate traffic, yet may be inadequate for heavy-traffic conditions, such as heavy loads or **high speeds**.

Ballast, which has been undisturbed for an extended period, except for the settling effects of rail traffic, will be relatively compacted.

Ballast, which has recently been placed in track or disturbed, will be relatively loose and have less restraining capability.

Shoulder ballast

Another condition which is insignificant from the longitudinal standpoint but of importance to lateral restraint is the **shoulder ballast**.

The amount and location of shoulder ballast, the type and compaction all determine effectiveness.

- This is another area in which you should become familiar with MARTA's standards or policy.

The standard also stated that ballast must restrain the track vertically. This capability has been discussed to some extent in terms of transmitting and distributing loads. It will be investigated further in parts of this lesson which follow.

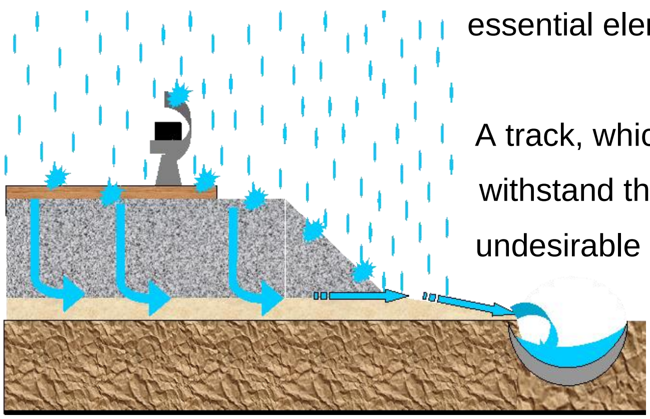
Drainage

Check slopes for possibility of slides and falling rock. Observe and note any slope erosion.

Ditches, catch basins, culverts must be clear of obstructions. All drains and catch-basins must be checked on each trip through the inspection area.

Any obstructions should be noted and cleared. Please note that catch-basins frequently clog after heavy rains. Please note any "standing" water.

Track must be supported by material, which will provide adequate drainage for the track. In these few words, the standard covers one of the most basic and essential elements of track maintenance.



A track, which is well drained, can withstand the effects of many other undesirable conditions for a considerable time without mishap. A poorly drained track will be expensive to maintain, and a constant threat to unrestricted train operations.

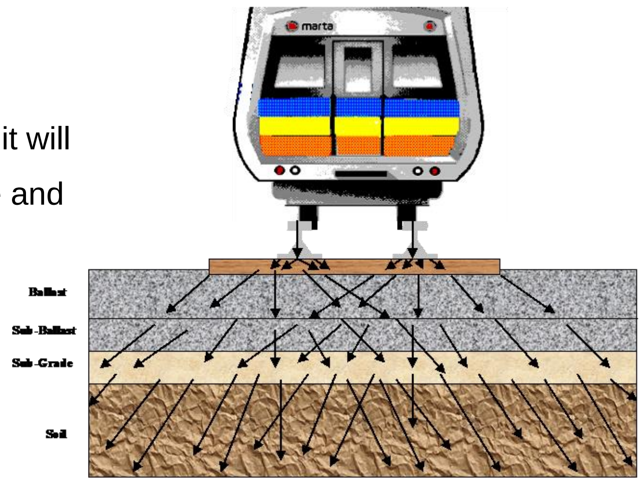
A poorly drained track is one in which moisture is prevented from escaping rapidly from the ballast, sub-ballast, and sub-grade.

- This may be caused by conditions within the ballast, which retain water.
- It may also be caused by roadway conditions beyond the ballast, which prevent the flow of water away from the track structure.

Crosslevel, Surface and Alignment

The fourth requirement for ballast, is that it will maintain proper track cross-level, surface and alignment.

- In effect, this summarizes the other parts of the standard.



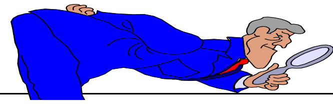
Proper crosslevel, surface and alignment are the goals, which are desired to achieve through maintenance of the ballast.

If the ballast properly transmits and distributes the loads placed on it; if it restrains the track laterally, longitudinally, and vertically; and if it provides adequate drainage, then the ballast will do its part in maintaining proper track geometry.

Tamping

One of the functions of a tie is to spread out the loads, which the tie receives from the tie plates.

Ballast has less ability to support a concentrated load than the tie. More area is needed for the ballast to support the tie than for the tie to support the tie plate.



It would, therefore, appear to be desirable to uniformly tamp the entire bottom area of each tie, thus uniformly distributing the load.

Unfortunately, if this is done, problems sometimes develop over a period of time. It should be realized that while a tie is relatively stiff.

- Under heavy loads some bending can take place.

This is particularly true of older ties. The result is that the ballast under those parts of the tie directly under the rail, gets a somewhat larger part of the load.

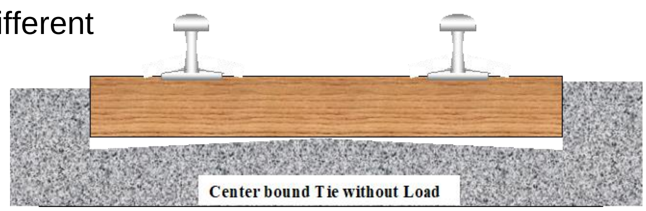
This ballast will therefore tend to compact and become depressed first.

The part of the tie, which is furthest from the rail, is at the center of the track.

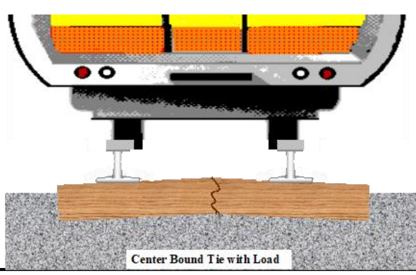
- If a tie is uniformly tamped throughout its length, the ballast at the center of the track will be the last to become depressed by repeated wheel loading.

When such a condition develops, the track can, in affect, pivot about the center of the ties. Such a condition is commonly known as **centerbound track**.

- The surface of centerbound track when subjected to the load of a train may be entirely different from its appearance when no train is on it.



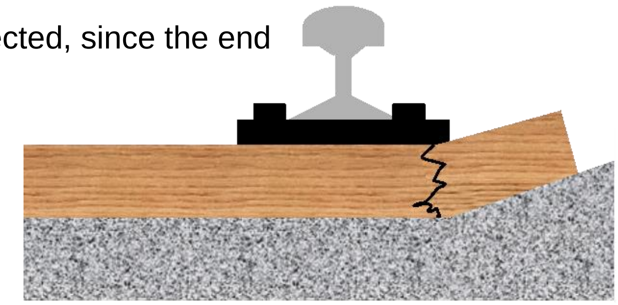
To avoid centerbound track, ties are not tamped in the portions close to the center. It is desirable to fill in any voids which may exist under this part of the tie, but not to compact such ballast.



Most tamping procedures do not compact the ballast under the tie between points about 1-1/2-feet inside the rails.

Another situation to be avoided is a tamping procedure which results in compacting ballast only under the portions of the tie outside of the rails. This can cause ties to break in the area under the tie plate or tie pad.

When this has occurred, it can be readily detected, since the end of the tie will slope upwards.



When manual tamping procedures are used, it is customary to give particular attention to the compaction of ballast under those portions of the tie directly under the rails.

- This is good practice, as compaction at these locations should be at least as great as under other portions of the tie.
- Most mechanical tampers accomplish this indirectly, rather than directly.

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Technical Training

Track & Structures

Track Inspection Training

Crossties

Section 4

CROSSTIES

A. Tie Replacement

Determining which ties will be replaced requires knowledge of several subjects. The ability to determine whether a tie conforms to the applicable standards is only one of these subjects. The fact that a tie does not conform to the standards does not of itself mean that it is necessary, or proper, for that tie to be replaced.

Determining Standards

Other facts that must be considered before making this decision include:

a) MARTA policy. Is to maintain minimum safe tie conditions in the track in question.
b) The maximum speed at which trains are permitted to operate at the particular location.
c) The number of **non-conforming** (ties or pads that fail to meet minimal standards for the intended class of track) ties in any 39 feet of track, which includes the tie in question.
d) The location of the tie in relation to a rail joint.

The first of these conditions implies that the policy for determining whether to replace ties may vary from one time to another or from one track to another.

- If this does happen, marking ties for replacement will be more difficult.

Fortunately, the minimum safe standards are well defined. Since there will be many times that you will have to work at the minimum safe standards, this lesson will deal with them first. Once you acquire a good knowledge of them, it will not be difficult to inspect ties to a higher standard, when desired.

Surface spalls, chips or broken out areas which expose the reinforcing wire or rods.

Cracked or otherwise impaired to the extent that it will not hold rail fastenings or rail fastening inserts. Special attention should be given to the insert area as cracks tends to start at one corner of the inserts and spread, leading ultimate tie failure.

Of special concern are ties, which support contact rail anchor assemblies. High stress can develop at these locations due to contact rail expansion and contraction. Ties which support contact rail insulators also are more highly stressed and should be inspected closely.

Concrete ties are also highly susceptible to damage from malfunctioning or dragging equipment. Inspect very closely when work has been recently done in the area.

Concrete ties also fail due to poor manufacturing quality control. For example, poor concrete will result in the tie crumbling. This problem will be seen as an area which develops many “shatter” or small cracks.

All loose or missing rail fastenings should be reported.

bond release beginning indicated by the recessed strands in the ends of the tie.

There must be a minimum number of acceptable ties on turnouts and curves for each 39 ft track section. An acceptable tie is defined as a tie that is able to maintain gauge, alignment and surface within the standards set for the intended class of track.

Wooden Crossties

Wooden crossties are located in turnouts, some hi-rail access areas and high speed transitions on the mainline. Please refer to the Turnout Inspection Procedures for inspection criteria.

Note any excessively split or rotten ties. Pay particular attention to the plate or fastener area of the tie. Tie failure is more prominent in the heelblock and frog area. A wood tie is considered failed when it is:

Broken through

Split or otherwise impaired to the extent it will not hold spikes or rail fasteners, or will allow ballast to work through.

So deteriorated that the tie plates or the base of the rail can move laterally more than 1/4”. If fasteners are re-anchored, tie plugs must be used before the spikes or lag screws can be replaced. In some circumstances it may be advisable to change the type of fastener so that the lag will have a different area of the tie to be lagged to.

Cut by the tie plate through more than 40 percent of a crossties thickness.

Direct Fixation Fasteners

Inspect daily. Defective fasteners are to be noted in the inspection report database.

The fastener is considered defective and should be reported as such, when:

The elastomer is poor or separated from any part of its components.

Any fastener component is bent, cracked, or broken.

Excessive lateral and or vertical movement is evident.

The rail hold down is defective or missing so that gauge cannot be maintained.

All anchor bolts and rail clips must be inspected. Note any loose or missing bolts and clips

Inspect the second pour for severe cracks and crumbling. All anchor bolts must be securely bonded to the concrete (2nd pour). Any areas of concrete failure should be noted on the Track Inspection Report.

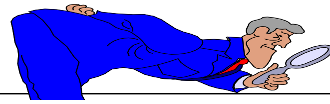
All railroads in the United States are required to comply with some standards for track maintenance.

Should any **condition** be present which does not meet these requirements, one of the following courses of action must be taken immediately.

a) Reduce the maximum permitted speed on the track so that the track will fall into a class for which the condition is permitted, then an appropriate slow order should be placed in effect.
b) If the condition in question is not allowable for the lowest class of track **(Class 1)**, repairs must be made that will bring the track into a class for which the condition is permitted, then an appropriate slow order should be placed in effect.
c) If the condition in question is not allowable for the lowest class of track **(Class 1),** repairs must be made that will bring the track into compliance for the class that the track is to be operated.

A qualified person may be a Track Foreman or other employee who has met certain requirements set forth by MARTA.

Failure to conform to the MARTA Track Safety Standards can result in the operation of trains on an unsafe track.



The Track Safety Standards will be referred to frequently throughout the balance of these lessons. A copy of the complete standards has been or will be furnished to everyone taking this course.

Before The MARTA Track Safety Standards can be understood, it is necessary to know what the various classes of track are.

Classes of Track: Operating Speed Limits.

If a segment of track does not meet all of the requirements for its intended class, it is reclassified to the next lowest class of track for which it does meet all of the requirements of this part. Crossties shall be made of a material to which rail can be securely fastened.

Each 39 foot segment of track shall have-

A sufficient number of crossties which in combination provide effective support that will-

(i) Hold gauge within the limits

(ii) Maintain surface within the limits prescribed.

(iii) Maintain alignment within the limits prescribed

The minimum number and type of crossties specified in paragraphs **(c)** and **(d)** of this section effectively distributed to support the entire segment; and

At least one crosstie of the type specified in paragraphs **(c)** and **(d)** of this section that is located at a joint location as specified in paragraph **(f)** of this section.

Each 39 foot segment of: Class 1 track shall have five crossties; Classes 2 and 3 track shall have eight crossties; and Classes 4 and 5 track shall have 12 crossties, which are not:

(1) Broken through.

(2) Split or otherwise impaired to the extent the crossties will allow the ballast to work through, or will not hold spikes or rail fasteners.

(3) So deteriorated that the tie plate or base of rail can move laterally more than ½ inch relative to the crossties; or

(4) Cut by the tie plate through more than 40 percent of a tie thickness.

Each 39 foot segment of track shall have the minimum number and type of crossties as indicated in the preceding table

CLASS OF TRACK	TANGENT TRACK AND CURVES ≤2 DEGREES	TURNOUTS AND CURVED TRACK OVER 2 DEGREES
CLASS 1 TRACK………………………....	………………5	……………….6
CLASS 2 TRACK………………………....	………………8	……………….9
CLASS 3 TRACK………………………..	………………8	………………10
CLASS 4 AND 5 TRACK………………...	………………12	………………14

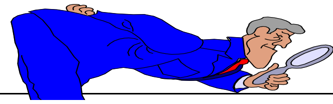
Crossties counted to satisfy the requirements set forth in the table of this section shall not be-

(1) Broken through;

(2) Split or otherwise impaired to the extent the crossties will allow the ballast to work through, or will not hold spikes or rail fasteners;

(3) So deteriorated that the tie plate or base of rail can move laterally ½ inch relative to the crossties; or

(4) Cut by the tie plate through more than 40 percent of a crossties thickness



Determining Measuring Lengths

For purposes of determining what is permissible in regards to the number of defective ties, the standard states the number of ties that are required in each 39 foot segment of track which do not have certain conditions which are described in the standard.

Measured Area

The 39-foot distance is a convenient one with which to work because of the predominance of rails of this length.

- Even if the rails are welded, the distance between welds can be used as the basic reference. In tracks with rails of other lengths, suitable allowance must be made.

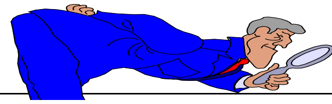
By stating the number of acceptable ties that must be present in each 39-foot segment for each class of track, **the standard eliminates discrepancies that would be caused by variations in tie spacing in different tracks.**

Within the crosstie standard, **part (b)(1)** states that there will be a sufficient number of crossties which in combination provide effective support that will

1. Hold gauge
2. Maintain surface
3. Maintain alignment

And within certain limits

4. MARTA Requirement must support the third rail.



Joint Ties

There are two types of tie layouts at joints. One is the suspended joint; the other is the supported joint.

The suspended joint allows the rail and joint bars to bridge the two joint ties.

- If the joint bars become loose, the rail will depress excessively between the two ties.

The irregular surface caused by this depression increases the pounding of the wheels.

In addition to further loosening the joint bars, this condition places excessive loads on the two joint ties.

- This can lead to rapid breakdown of the ballast support under the tie, greatly shortening the tie life.
- If a joint bar becomes loose over a supported joint, the center joint tie usually gets the brunt of the load.
- In time, as the tie deteriorates, or as the ballast support under it fails, the load is passed to the two adjacent ties.

A bad joint tie condition not only contributes to rail end batter, joint bar and bolt failure; it can also be the source of gauge and surface problems.

To recap – it is important that all mud be cribbed from pumping joints and replaced with clean ballast and properly surfaced.

Crossties at Rail Joints

Classes 3 through 4

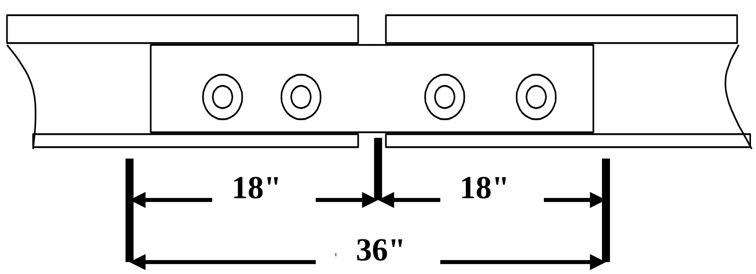
Each rail joint in **Classes 3 through 4 track** shall be supported by either at least one crosstie specified in paragraphs **(c)** and **(d)** of this section whose centerline is within 36" shown above, or:

Two crossties, one on each side of the rail joint, whose centerlines are within 24" of the rail joint location shown above.

For track constructed without crossties, such as slab track, track connected directly to bridge structural components and track over servicing pits, the track structure shall meet the requirements of paragraphs (b)(1)(i), (ii), and (iii) of this section.

The crosstie standards are written in a manner that permits them to be applied to all crossties, regardless of the material of which they are constructed.

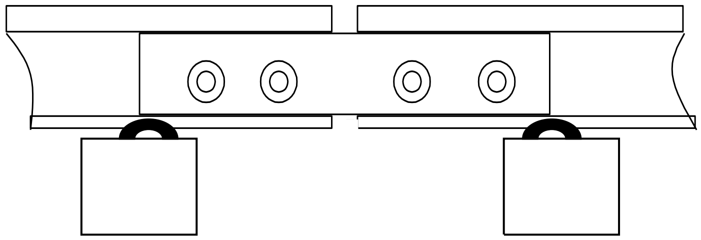
- Although the great majority of crossties are made of wood, some railroads are using concrete, at least on a limited basis.



These standards also recognize that there are other types of fasteners in use, in addition to the conventional track spike.

Suspended Joint

Note the arrangement of the ties in drawing below, you will see that there is no tie located directly under the rail ends. This arrangement is known as a **suspended joint**.



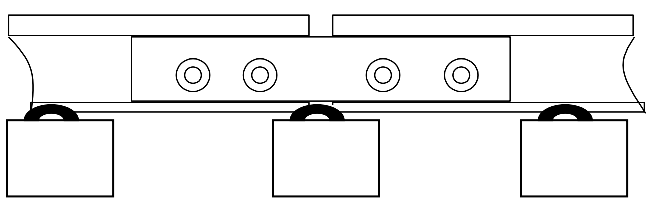
Suspended Joint

With a suspended joint, there will ordinarily be one tie on each side of the center of the joint within the specified distance.

Only one of these two ties must be free of all of the undesirable conditions listed in the MARTA Standards in order to meet the joint tie requirement.

Supported Joint

There is a different arrangement of ties at a supported rail joint. In this case, there is a tie directly under the center of the joint. This is known as a **supported joint.**



Supported

With the 18 inch limitation for track of **Classes 3 to 5,** if normal tie spacing is used, this center tie is the only one that can be considered when applying the joint tie standard.

This type of inspection is more complex than merely determining whether each tie is defective or not. Because of this it will take more practice until you become competent in the inspection of ties.

- This skill will probably not be mastered quickly, but it is among the most important skills required of a Track Foreman, Track Maintainer or Track Walker.
- All that it takes is plenty of practice and reference to this lesson as necessary.

Acceptable Ties

It may be of interest to note that the four conditions **are not referred to as defects.**

- This is done for a very good reason.

Persons who do not have a good knowledge of track would tend to assume that something that is identified as being defective is unsafe and should be replaced immediately. In the case of crossties, this is not necessarily so.

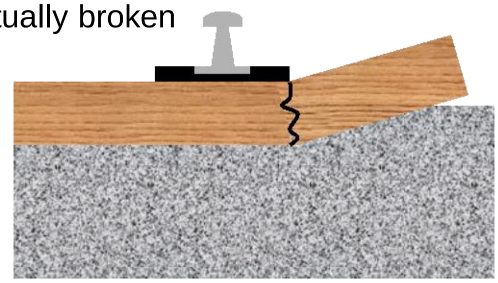
- The crosstie standard states the limits of safe conditions. It would be uneconomical and inefficient to replace every tie as soon as it deteriorates to a condition described in part **(c).**

At this point, the conditions described in part **(c)** of the standard should be considered.

The first condition which will cause a tie to be excluded from the count of acceptable ties is that of being broken through.

This usually occurs under the rail.

In such cases, the break is across the tie. It can be readily recognized because the tie slants upwards from the tie plate or pad to the end of the tie.

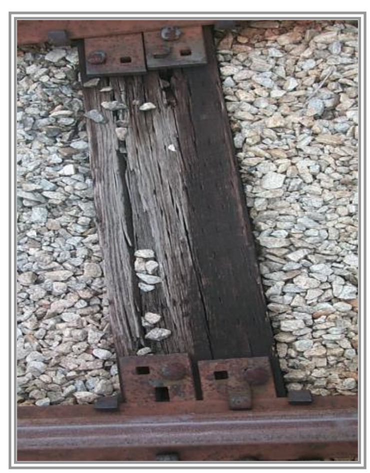


- Usually this part of the tie is not actually broken off, but it has no strength for supporting a load.
- Also this end of the tie may stick-up enough to damage a collector shoe.

Occasionally, ties may be broken in other locations as a result of a derailment. Any tie with such a condition cannot be included in the count of acceptable ties per 39-feet, nor as an acceptable joint tie.

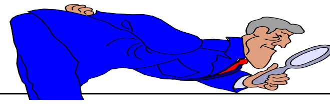
The second condition that of being split or otherwise impaired to the extent the crossties will allow the ballast to work through, or will not hold spikes or rail fasteners, actually includes several conditions.
Many wood ties contain small splits.

- These generally are not detrimental unless they become large.
- If a split is of a size that permits ballast to work up into the split, the tie will have a reduced capacity for maintaining surface.
- In addition, the working of ballast into the split will probably cause the split to enlarge.



There are several conditions that will cause a tie not to hold spikes or rail fasteners.

- One of these is being split through a fastener hole.
- Elongation of the fastener holes as a result of lateral wheel forces, which attempt to widen the gauge is another cause.



The holding power of a rail clip is reduced as a result of several cycles of removal and replacement of the fasteners in connection with operations such as rail renewal, gauging or lining.

The same can also happen to lags. The holding ability of the lag will be reduced with the removal and replacement of the lags without ether plugging the hole or moving the pad to a different spot to re-lag.

Rail holding fasteners in sound wood ties, particularly cut spikes, frequently raise slightly off the base of the rail.

- This is caused by the wave action of the rail as wheels move along the rail.
- This can occur early in the life of the tie, and the fastener may not continue to raise for many years.
- This condition is normal and acceptable.

On the other hand, a spike or lag, which has raised several inches out of the tie or which is loose will no doubt be considered as not holding. The standards do not state at what point a partially raised fastener is one that is not holding. This becomes a decision based on judgement.

CONCRETE CROSS TIES

The tie is an important part of the track structure. The purposes of a concrete tie, is the same as a wooden tie.

And that is:

1. Support the rail.
2. Helps hold track to proper gauge.
3. Distributes the weight of a train over a large area by transferring weight from rail to ballast and ballast to roadbed.

4. Helps hold rail in place during temperature change.
5. Helps keep track in proper cross level.
6. Support the third rail.

Skewed and bunched ties are generally good ties in a location where rail has moved on account of insufficient anchors or ballast lacking between ties following tie installations.

- Check the gauge for tight gauge condition and watch for a low muddy spot developing in the track surface.
- Be sure both examples comply with MARTA rules.

Hanging ties are not necessarily defective ties; however, they can cause rocking action for trains. Critical places to inspect are:

- At both standard and insulated joints.
- At field welds.
- Near grade and rail crossings.
- At bridge ends and aerial structures.
- Ahead of switches and behind frogs.
- On curves.

Concrete Tie Failure

The failure of concrete ties may be categorized into two different mechanisms:

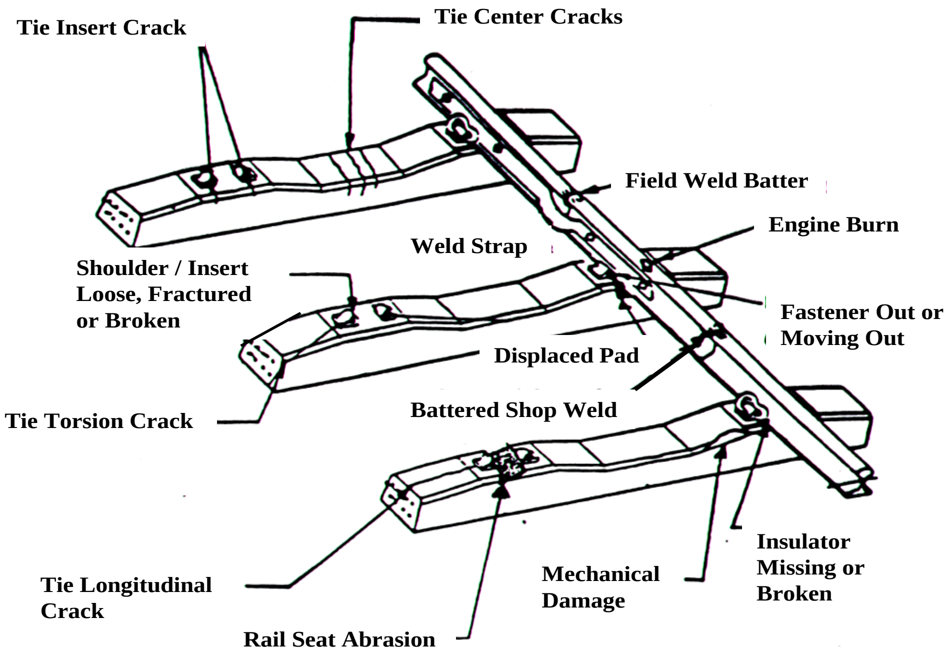
a) Mechanical wear b) Damage.

a) **Mechanical Wear**:

Failed ties in this category include not only the tie itself, but also the fastening systems. Since failure of the fastening systems result in loss of electrical integrity, loss of gauge, and loss of longitudinal strength:

Worn/broken or missing insulators, worn or loose shoulder castings, worn or missing pads, bottom abrasion, and rail seat abrasion.

- **Worn/broken or missing insulators***:*
  Movement of the rail in the rail seat both laterally as well as longitudinally can cause the insulators (especially on the field side) to be abraded or crushed over time. The portion of the insulator between the shoulder casting and the rail base can be worn away allowing the rail base to contact the shoulder casting. This results in loss of electrical insulation as well as wide gauge. The insulators must be replaced when this condition occurs.
- **Worn or missing pads***:*
  Vertical loads, as well as longitudinal rail movement can abrade or crush the tie pad or even move the pad off the rail seat. If this happens and the rail is allowed to contact the concrete rail seat, rail seat abrasion or aggregate fracture can occur resulting in rail seat failure. This can be aggravated by the presence of high impact loads from improperly maintained wheels, a rail joint, or badly surfaced welds.
- **Bottom abrasion***:*
  Concrete ties will, over time become abraded by rubbing action against the underlying ballast. This will result in a loss of depth and bearing area under the tie that could cause the tie to fail under load. The loss of concrete on the bottom of a tie will not adversely effect the integrity of the tie until enough material has been removed that the pre-stressing wires are exposed. Once this happens, the tie should be removed.
- **Worn or loose shoulder castings***:*
  If the insulator is not replaced once the post has been worn away, the rail base continues to cut into the shoulder casting resulting in loss of shoulder strength, and wider gauge, and could result in shoulder failure.



Rail seat abrasion:

The actual cause of rail seat abrasion is not fully understood, but one theory is that silts or fines, mixed with water, find their way under the tie pad. With each passing wheel, the mixture creates a suction between the tie pad and the concrete rail seat which draws the cement out of the concrete, exposing the aggregate. The exposed aggregate penetrates the tie pad and is subject to abrasion and fracture upon making contact with the rail base. This process results in a lowering of the rail seat which in turn causes a reduction in toe load from the rail clips. Lateral loading on the rail accelerates the abrasion on the field side of the rail seat resulting in wide gauge due to rail roll. If this occurs, the rail seat must be repaired or the tie replaced.

Damaged Ties:

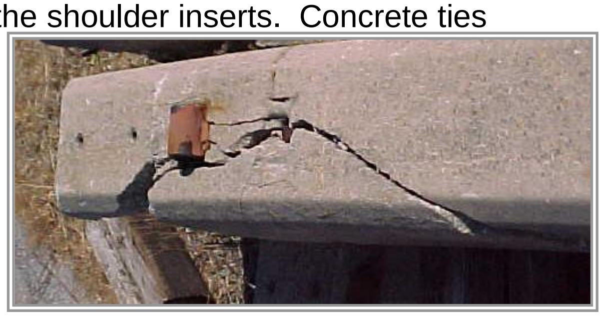
Failed ties in this category include: Broken shoulder castings, frozen and broken-in-place hold-down clips, broken ties.

- **Broken shoulder castings**:

  Dragging equipment, a derailed wheel or

mishandling of the tie can result in the shoulder casting being struck. The casting can be broken off from the insert or the stem may become loosened inside the tie. In either case, the tie has failed and must be replaced.

- **Frozen and broken-in-place hold-down clips***:*
  Dragging equipment, a derailed wheel or over driving the clip can result in a broken clip. If the portion of the clip inside the shoulder casting cannot be removed, the tie must be replaced. In some cases, if ballast is allowed to remain covering the clip and shoulder, the clip can rust inside the shoulder. Removal of the clip may become impossible without breakage of the clip and/or the shoulder. Should this occur, the tie must be replaced.
- **Broken ties:**
  Dragging equipment, a derailed wheel, or a falling equipment can smash a concrete tie. In addition, severe skewing of a tie can result in the tie splitting end to end through the shoulder inserts. Concrete ties that become center bound, putting the tie into reverse flexure will also break in the middle. Ties in this condition must be replaced



Tie and Direct Fixation Fastenings

Direct Fixation Fasteners

Inspect daily. Defective fasteners are to be noted in the inspection report database. The fastener is considered defective and should be reported as such, when:

The elastomer is poor or separated from any part of its components.

Any fastener component is bent, cracked, or broken.

Excessive lateral and or vertical movement is evident.

The rail hold down is defective or missing so that gauge cannot be maintained.

All anchor bolts and rail clips must be inspected. Note any loose or missing bolts and clips. If more than five (5) in a row, notify Track and Structures Supervisory Personnel ASAP.

Inspect the second pour for severe cracks and crumbling. All anchor bolts must be securely bonded to the concrete (2nd pour). Any areas of concrete failure should be noted on the Track Inspection Report.

Four Pandrol clips per tie must be installed. Care must be taken to drive the clips correctly.

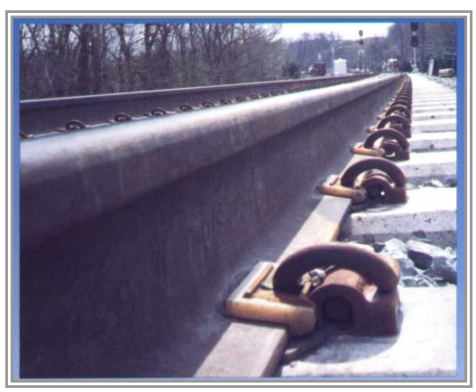
- Clips must be driven so that no more than 1/8" of the center leg protrudes through the shoulder.

All **e series clips** must be driven so that the center leg is flush with the edge of the shoulder.

Where clips are installed by hand, care must be taken not to strike the cast-in-place shoulder or tie with the striking tool.

- Where clips are installed by machine, the operator must ensure that the machine is adjusted to thrust the clip horizontally into the hole without binding.

Machinery not specifically designed to remove Pandrol clips must not be used for removing clips out of face in areas suspected of having frozen or rusted clips, such as tunnels, areas of blowing sand, and wet areas.



- If any clips are found rusted in, excessive force must not be used, as such will break the tie or shoulder.

- An application of penetrating oil a day in advance of clip removal will assist in loosening some clips.

To avoid damage to the insulator post or possible shattering of plastic insulators, insulators must not be forced into position by hammering. A rail positioner tool must be used to provide a suitable gap between the shoulder and the base of rail for the post of the insulator.

Concrete Tie Components

Pandrol Holding System

Pandrol concrete tie assembly components (shoulder, insulator and tie pad) function as an integral unit to securely fasten the rail to the tie.

Pandrol shoulders are made from ductile iron. Designs are available for the pad thickness of 5mm, 6.5mm, and 10mm. All shoulder designs meet or exceed AREA standards for pullout resistance.

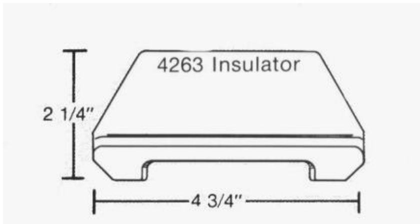
Pandrol offers two insulator designs: the 4263 for normal service conditions and the HD-10 for heavy duty service. Both are made with high impact resistant thermoplastic materials with excellent compressive and tensile strength. The HD-10 has a metal casting insert for added strength and stability.

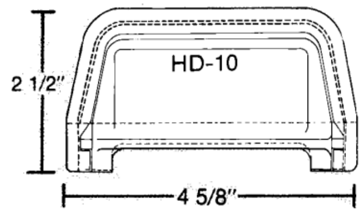
When used in conjunction with Pandrol rail clips these components assure rail/tie unification and excellent track stability.

Rail Insulators

Made from tough thermoplastics with excellent compression and tensile properties.

Available in standard (4263) or heavy duty (HD-10) designs.



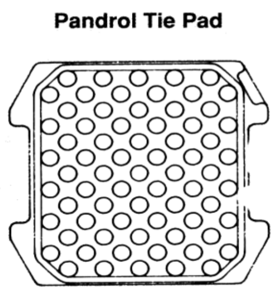


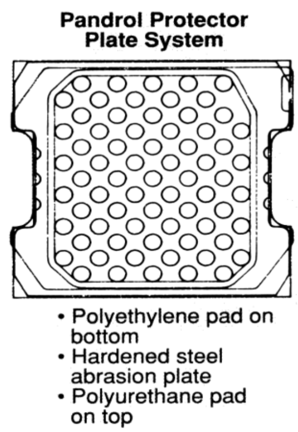
Tie Pads

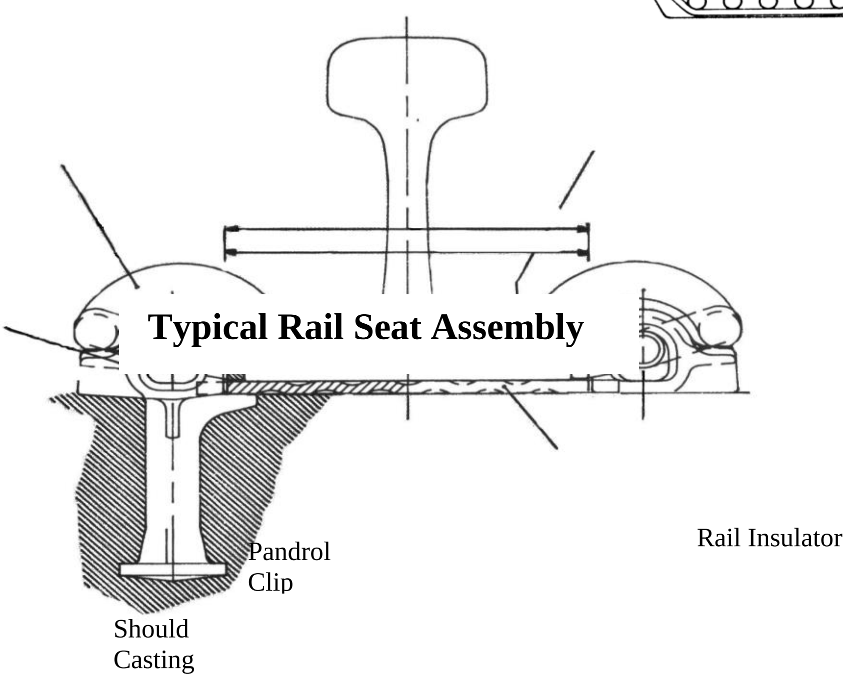
Made from high quality EVA, polyurethane, rubber or specialty compounds depending upon application.

Thickness of 5mm and 6.5mm. Dimensions and geometric pattern will vary with rail size and service conditions.

Designed with sealing ring to prevent intrusion of sand and water into the rail

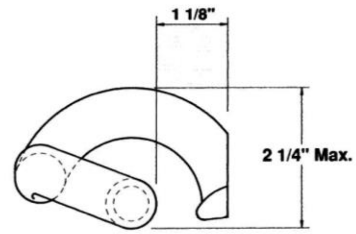






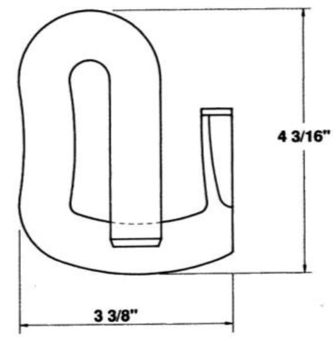
Pandrol Fasteners

Pandrol offers a wide variety of clips specially designed for use at track joints, where joint bars interfere with standard Pandrol clips.



The "e" clip design utilizes the toe to bear on the rail foot.

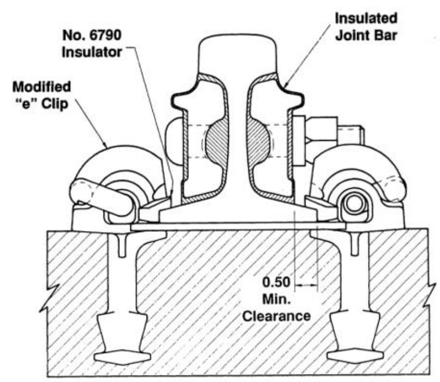
The modified 'e' clip will accommodate joint bars where sufficient rail foot area is exposed. (See drawing). The modified 'e' clip installs easily and provided a high clamping force.



Working deflection compensates for normal manufacturing tolerances and component wear.

"e" Series Clip

- Made from high quality spring steel bar stock.
- Bar diameter: 20 mm ("e" 2000 series)
- Approximate shipping weight: 1.6 lbs.
- Normally packed 50 per bag.



CONCRETE TIE

The **"e"** series clip with its unique geometric design offers a light weight, low cost rail fastener. Spring and torsion work together to provide a high clamping force, excellent resistance to rail rollover and longitudinal restraint.

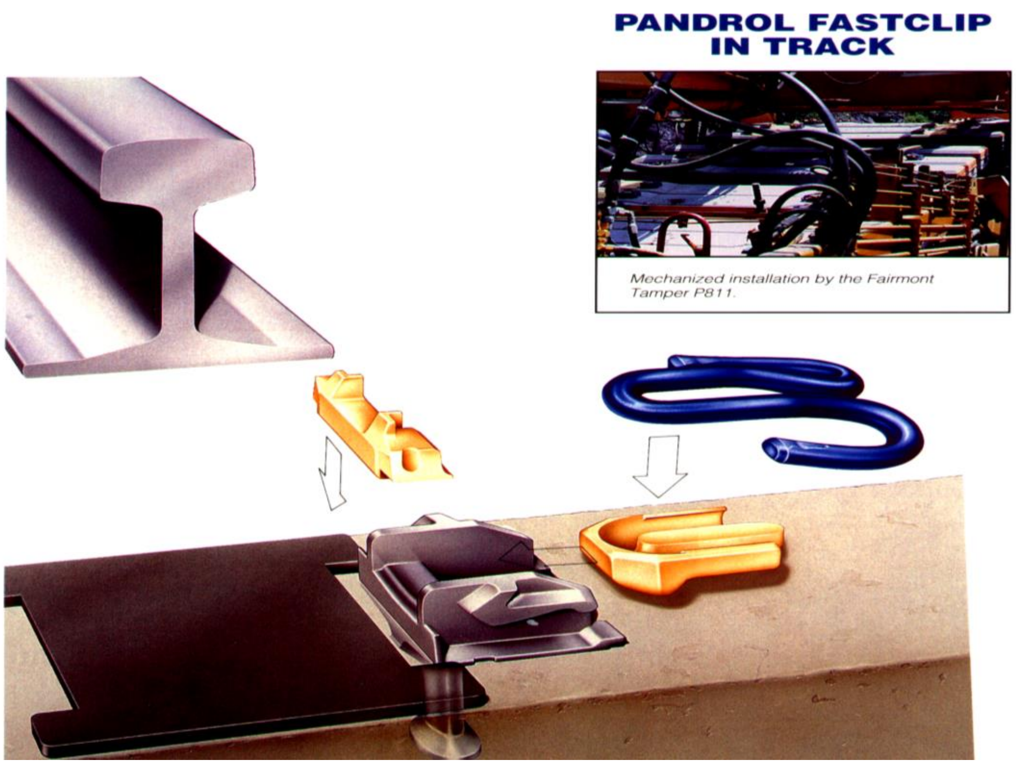
The "e" clip is driven parallel to the rail and is easily installed, manually with standard track tools or mechanically with magazine fed, high speed, automatic production equipment.

Pandrol Fast-Clip

The Pandrol Fast-Clip is new in every respect: concept, performance, and benefits.

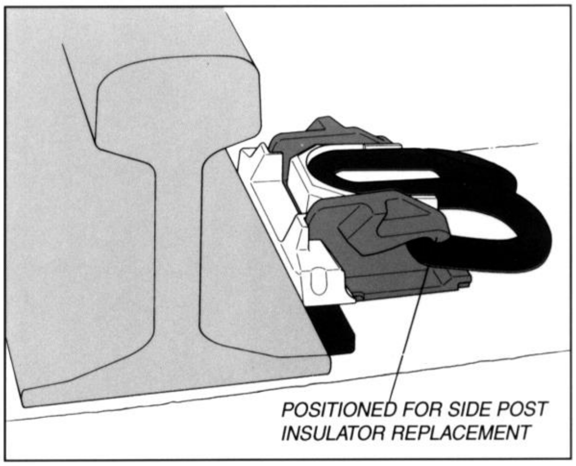
Fast-Clip was computer-developed, taking into account the many factors that affect track performance and translating these factors into a fastener design that fully addresses those requirements.

From the laboratory to in-track service, Pandrol Fast-Clip has met or exceeded every test and performance demand.

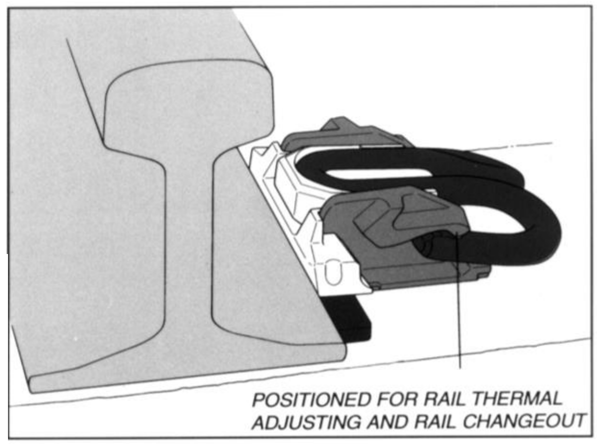


FastClip comes pre-assembled on concrete ties, with pad, insulators, and clip ready for track installation. It remains on the tie for its entire service life, even during rail change-out and rail thermal adjusting.

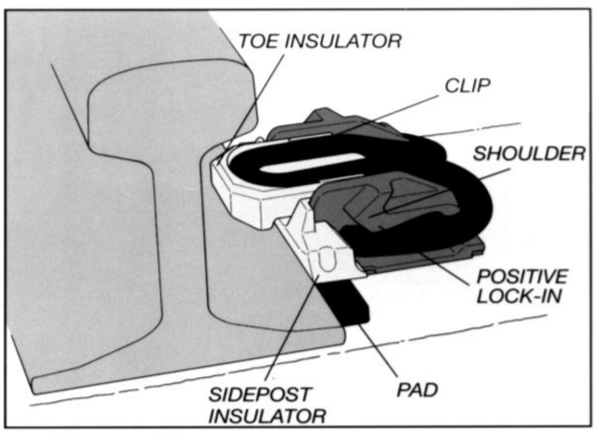
The rail-ready FastClip system significantly reduces installation costs. Once in service, maintenance costs are minimal.



MAINTENANCE POSITION



RAIL-READY POSITION
(As supplied by concrete tie manufacturer)



INSTALLED POSITION

So far, we have been considering the vertical loads, which are placed on the various parts of the track structure.

In addition to the part played by the tie in supporting these vertical loads, a number of other types of loads are placed upon the tie.

One such load is that which tends to spread the rails outward, increasing the gauge.

- Such loads may be minor or may be very great.

Defective Ties

Defective ties shall be identified and marked for replacement.

Ties with any of the following conditions shall be considered defective:

(i) Tie broken transversely under one or both rail seats.

(ii) Tie broken transversely between the rail seats and showing signs of further deterioration (loss of tension in pre-stressing wires, exposure of wires, crumbling. Etc.).

(iii) Tie broken longitudinally resulting in loss of ability to hold cast shoulder(s) in place.

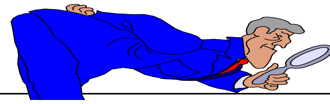
NOTE: Cracked ties should not be confused with broken ties. A tie is not broken until the crack extends through the entire depth of the tie.

One or more shoulders are loose. Broken or damaged shoulders such that the clips will not remain in place or cannot be inserted.

NOTE: Quite serious damage can be done to the tie ends without seriously affecting the performance of the tie.

Concrete ties can be worn from the bottom of the tie to the lowest level of pre-stress wires. This should be considered an unacceptable tie and will need to be replaced.

For **Class 4 track**, there must be no more than four (4) defective ties in any 39 foot length of tangent track and there must be no more than two (2) defective ties



in any 39 foot length of curved track with no more than two (2) defective ties in a row. At least one of any two adjacent defective ties must provide vertical support to the rail.

Ties must not be allowed to become center bound (transverse cracks in the middle third of the tie indicate a center bound condition).

Disturbed ballast in cribs, skewed ties and/or bunched ties are indications of rail movement. The cause must be determined by inspecting the condition of insulators, tie pads, clips and any other unusual conditions.

Skewed ties must be straightened and worn or defective components must be replaced.

In areas with soft sub-grade where rail movement and poor tie spacing are evident, it may be necessary to install rail anchors which, are approved for use with concrete ties, to control rail movement.

A standard ballast section, with full cribs, must be maintained at all times, but ballast shall not be left around the clips and the clip shoulders castings.

Track gauge must be measured frequently and the cause of any wide gauge must be determined. Inspect the condition of the insulators, tie pads and rail seats.

- Wide gauge must be corrected by changing the field side insulators and replacing worn tie pads.
- If the cause of wide gauge is rail seat abrasion, the condition must be reported.

Ties at bonded insulated joints must be kept tamped and the track in good surface and cross level.

- Rail slotting at bonded insulated joints shall be carried out as required.

Broken or missing clips must be replaced as soon as possible.

- Defective or missing pads and insulators must be replaced as soon as possible.
- Pads and insulators that have worked out of position must be repositioned as soon as possible.

Lateral Movement of the Rail Fasteners or Tie Plate

Lateral movement of the tie plate or pads or base of rail can usually be determined without much difficulty.

- If a tie plate or pad is moving laterally under load, this can be determined from evidence of wear on the top of the tie just beyond the field side edge of the tie plate or pad.

If the tie plate or pad has moved and does not return to its original position when there is no load on the rail, the evidence will be on the top of the tie or the second pour, just beyond the gauge side edge of the tie plate or pad.

The extent of such movement can be readily measured. The field side shoulder of the tie plate not being against the base of the rail can be evidence of the rail moving laterally under load, independent of the tie plate. This too, can be measured without difficulty.

Applying Standards

It will be essential that you carefully study these Standards that specify when a tie is non-conforming. You will then need to practice the application of these standards.

- This can be done by inspecting the condition of ties in conveniently located tracks. The idea is to judge each tie on its own merits, and to determine whether or not this tie meets the standards.
- You will probably find that some ties which you would consider to be sound, must be classified as non-conforming under these standards.
- You may also find that some ties which show a good deal of deterioration are acceptable under the standards.

As you look at each tie, remember that you are judging it only in relation to the **MARTA Standards**.

Not your personal opinion.

One way in which you can tell if you are consistent is to count the number of ties you judge to be defective between two fixed points.

- These points should be a good distance apart, say one-quarter of a mile.
- The tally can be made either by notes on a piece of paper or by a mechanical counter.

Remember not to make any marks on the track structure. Later, make a second inspection and count of ties in the same track between the same fixed locations.

The first and second count probably won't agree exactly, but if they are close you will know that you are developing consistency in your inspection.

Crossties to Be Replaced

Once you become competent at judging each tie on its own merits, you are ready to start determining which of the ties that do not confirm to MARTA Standards should be replaced. In order to do this, it is first necessary to determine the class of track in which the ties are located.

If the tie inspection is being made for the purpose of determining that the minimum safe standard is being maintained, these are the standards to which your inspection will be directed.

- It is recommended that you practice inspecting ties on this basis at first.
- Continue to do this until you become very familiar with the procedure.

The first part of this procedure is to determine which of the ties in a 39 foot segment have one or more conditions which will not permit it to be included in the count of acceptable ties.

Once these have been identified, the second part of the procedure is to determine how many acceptable ties are in the 39 foot segment.

- If there are not enough acceptable ties, the next step is to determine which ties should be replaced in order to attain the minimum acceptable number.

These decisions need to be balanced between various considerations. One of these considerations is the extent of the deterioration of the ties. Other things being equal, it is only natural to decide to replace the ties in the poorest condition.

However, suppose the tie in the poorest condition has a good tie on each side of it. Suppose that within the same 39 foot segment, there are several consecutive ties, not as badly deteriorated as the single tie located between two good ties, but all having one or more of the conditions that will eliminate them from the acceptable category.

Under these conditions, it would be preferable to install at least one tie near the center of this group of ties.

- Basically, the procedure is to make a complete evaluation for each 39-foot segment before moving on to the next segment.

There are ways in which ties may sometimes be handled that can seriously reduce their self protective capability.

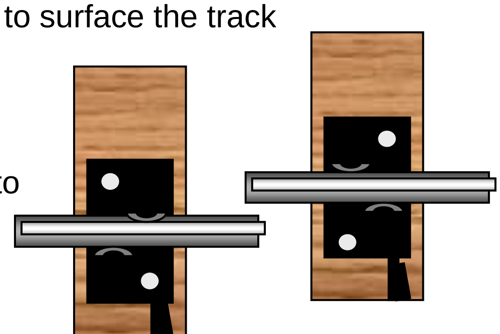
1. Gouging of ties as sometimes happens when handled with equipment such as a clamshell bucket can expose the interior of the ties to organisms which cause decay.
2. Failure to plug the holes left when spikes or lags are pulled can have a similar effect.
3. Spike or lag holes are also excellent places for moisture to accumulate. This can result in softening of the tie in the critical area under the rail. In freezing weather it can be a cause of splitting of the tie.
4. Adzing of the tie plate seats when gauging or replacing rail without applying a coating of a preservative to the adzed surface can shorten the life of the tie.

There are also a number of ways in which proper maintenance can prevent premature failure of a tie due to the effects of traffic.

- In many cases, joint ties are found to have a shorter life than ties not under a joint.
- Breakdown of the ballast support under the joint allows greater vertical movement of the tie as wheels pass over the rail at that point.

This breakdown of the ballast support is attributed to three possible causes:

1) It may be caused by the pounding from batter on the rail ends
2) Excessive flexing of the joint due to loose bolts or worn joint bars
3) It may be the result of simply failing to surface the track at reasonable intervals.



If such vertical movement of the tie is allowed to continue, there are a number of ways that the tie may fail.

1) One of these ways is through plate cutting. It is shown in a previous lesson that the use of plate-holding spikes can help control plate cutting, but this practice can't completely protect against the effects of excessive vertical movement of the tie.
2) Another way in which a tie subjected to such stresses may fail is by loosening the bond between the tie and the spikes or lags.

- In such cases, the spikes or lags will raise up and may become loose enough to remove by hand. If the tie is otherwise sound, this condition can be corrected, and the life of the tie extended.

- The spike should be removed and the hole plugged.

- If there is an unused hole in the tie plate of the same category (such as a field-side rail-holding spike), it may be preferable to install a spike in that location.
- If not, the spike or lags can be re-driven in the plugged hole. Standards might be brought into compliance quickly.
- Or exchange the pad with another that has the lag on the opposite side of the pad. That way the lag is going into a solid section of the tie.
- Remember to plug the old lag hole.

If there is a split beginning to develop in the end of a tie, and the tie is subjected to excessive vertical movement under traffic, failure may occur in yet another way.

- Pieces of ballast can be forced into the split causing it to widen further. It then becomes even more likely that ballast will enter the split until the tie opens up to the point of complete failure.

Such a constant movement of timber against ballast can have an abrasive effect.

This can wear off the bottom surface of the tie considerably reducing the thickness of the tie. It is not unusual where such conditions have existed for sometime under heavy traffic, to find that the tie has been reduced to about half of its original thickness.

Proper maintenance of joints can considerably reduce the tendency of joint ties to develop any of these types of defects.

Other locations where the life of ties is sometimes reduced are curves, particularly the sharper curves.

- If trains move through a curve at or close to the maximum permitted speed, there will be a considerable lateral force exerted by each wheel against the **outer** or **high rail** of the curve.

If the high rail is not securely fastened to the ties, these lateral forces can cause widening of the gauge.

- It must be remembered that tie plates permit all the spikes in the tie plate to resist such movement.

Visual evidence that gauge is widening includes noticeable wear on the tip of the tie at the edge of the tie plate or pad and the condition where the field side of the plate shoulder is not flush with the base of the rail.

If the ties are not sound or if there are not enough spikes to resist the lateral wheel forces, the spike holes will become elongated.

- This permits the tie plate and the rail to move to the field side resulting in a wide gauge condition.

This tendency may be gradual or if excessive lateral forces are applied it can be sudden. When such a gauge-widening tendency is detected, the usual practice is to:

1. Pull the spikes or lags.
2. Plug the spike or lag holes.
3) Reposition the rail fasteners or tie plates to proper gauge.
4) Re-spike or lag.
5) Driving of additional spikes to increase the holding power of the ties.
6) Change pads to ones with the lag on the other side of the pad for a sound section of the tie to lag the pad to.

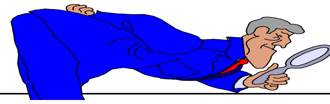
Technical Training

Track & Structures

Track Inspection Training

Rail

Section 5



RAIL

A. 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 weighs 115-pounds** and that its shape is according to the design recommended by the **American Railway Engineering Association. (AREA)**

We here at MARTA have only one rail size, that is **115 pound RE rail**.

Rail Brands

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.

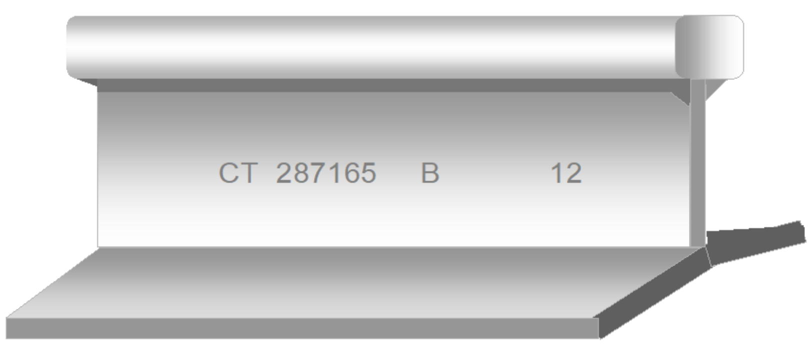
An example would be as follows:

- 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

On the other side the characters are indented.

Following is an example:



- CT 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 ingot number

Rail

MARTA's running rail is standard AREA 115RE section. This rail must be inspected daily in conjunction with the regular walking semi-weekly Track Inspection. Any and all rail defects must be noted in the Track Inspection Database utilizing the information found in the MARTA Track Safety Standards as a guide. All visible cracks, which extend beneath the surface of the rail, should be reported to Track and Structures supervisory personnel ASAP, and the operating speed reduced to 10 M.P.H. In addition, the Trackwalker must flag all trains through the defect area. Upon arrival, supervisory personnel must decide if the slow order should remain in effect, if normal operations should be restored, if joint bars should be applied to the defective area, if the track should be removed from service until the defective rail can be replaced, or any combination of the above.

Internal Rail Defects

In the case of visual inspection, internal defects are not readily visible unless they have resulted in a break in the rail or a breakout of a section of rail. Therefore, when this type of defect is found through routine visual track inspection, they are generally quite significant and may require immediate action. For more information on these defects, refer to the MARTA Track Safety Standards. All revenue tracks are ultrasonically inspected at least semi-annually to locate internal defects.

Rail Wear

Rail should be carefully inspected for gauge face wear. This is extremely important in curves and is almost always observed on the outer (high) rail. The following inspection standards apply. Annual rail wear inspections will be made by Track Supervisory Personnel. All locations with excessive rail wear should be reported and brought to the attention of Track Supervisory Personnel for verification.

Rail Types

All MARTA rail is AREA 115RE section, but there are different metallurgical types. Listed below are these types and their identifying marks. This information must be included on all Rail Defect and Replacement Report forms.

Control Cooled. - All rails are control cooled, but this is usually used to describe standard hardness and metallurgical content rail. On the MARTA system this rail is usually located on tangents and shallow curves. There are several mill markings, including, Tennessee; Algoma CC 1988; Workington; Wheeling Pittsburgh.

Head-Hardened Rail - This rail is control cooled rail with the rail head being heat treated to increase its strength. This rail is used in turnouts, curves, and station platforms. This rail cannot always be identified by markings, but some can be identified by the following: Illinois, US Steel, and CF&I Head Hardened which has metal tags attached to the rail web.

Chromium Alloy. This rail has a high chromium content to improve wear characteristics. This rail is found on the North Line between Arts Center and Brookhaven, and on the South Line between West End and East Point. This rail is stamped Workington 1 CR.

Chrome/Moly Alloy. This is another alloy rail formulation and is found in the CY154 (East Point to Airport & Brookhaven to Chamblee) area. This rail is stamped Wheeling Pittsburgh WWR.

Rail Lubrication

The rail must be inspected for proper lubrication in conjunction with the scheduled walking inspection. This is extremely important in curves. .

Rail Lubricators

Inspection of rail lubricators and lubricant is a very important part of the daily inspection process. Rail is the single most expensive part of the track, and proper rail lubrication helps us to extend the life of the rail.

- The goal is to have grease on the gauge corner of the rail, but not on the top of the head of the rail, as this will interfere with train braking.
- The Rail Lubrication Report must be completed daily.

Lubricators must be kept operational and adequately supplied with the proper lubricant. The grease at every lubricator within your daily inspection area should be stirred with the clean paddle stored in the tank.

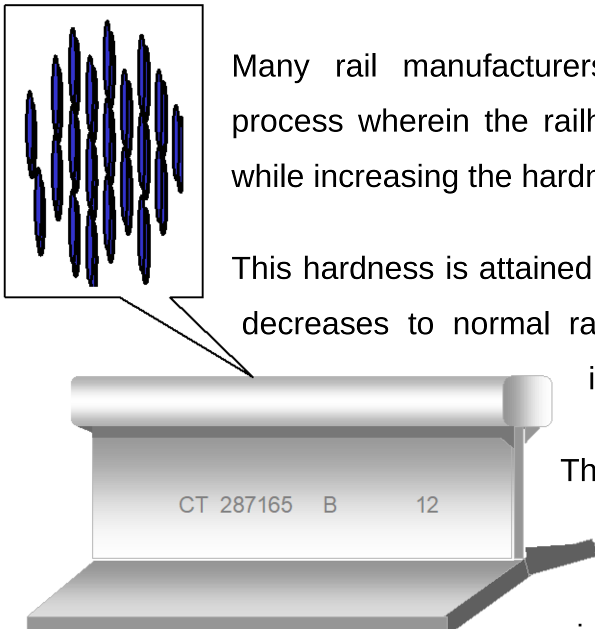
- This must be done daily.

The top of the railhead should be checked at a location 500 ft. from the lubricator in the direction of train traffic. The amount and location of the grease on the head of the rail should be a good indication as to how the grease is being carried.

The carry-curve for the lubricator also must be checked for the proper amount of lubricant. The carry-curve is the last curve the lubricator services before the next lubricator. The condition of the lubricant on each carry-curve should be noted and highlighted on the regular Track Inspection Report.

All repairs and modifications to the rail lubricators will be done on an as needed basis by trained and qualified rail lubrication personnel.

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.

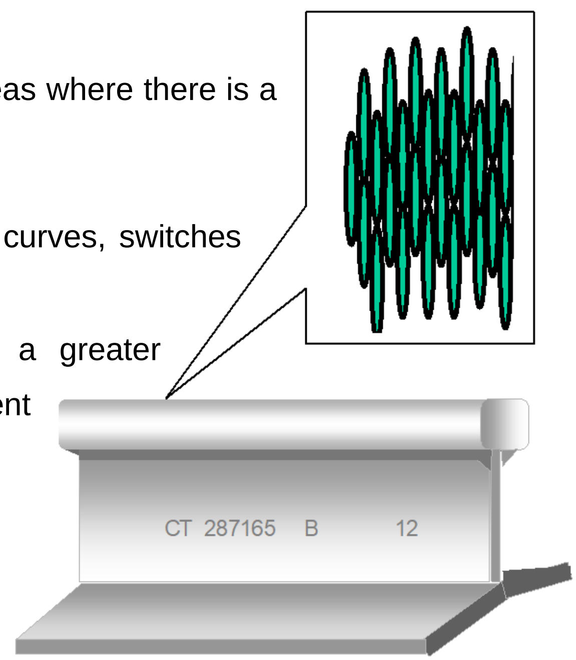
The process involves induction heating of the rails followed by sequential compressed air cooling. This results in increasing the service life of the rails.

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.



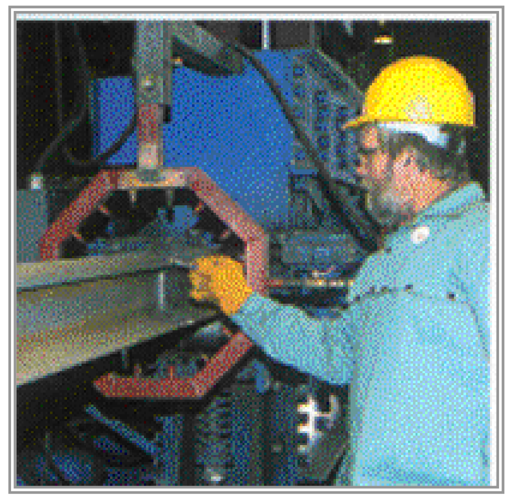
Surface Hardness

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 result fails 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.

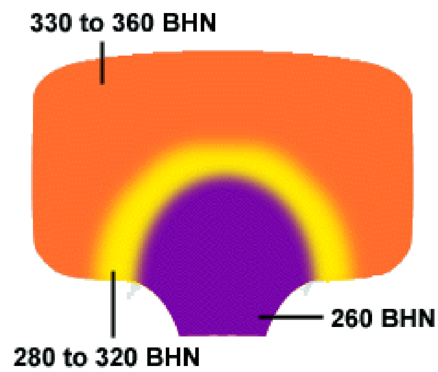
- Both of these checks must be satisfactory for the heat or lot to be accepted.
- If any one of these two checks fails, individual rails may be tested for acceptance.

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.

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.

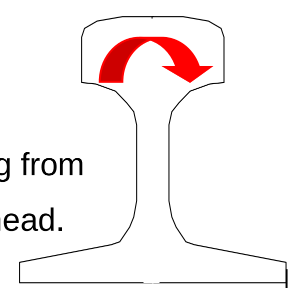
If the results for heat-treated high-strength rail fail to meet the requirements, the rails represented by the test may be reheat-treated and re-tested.

Section

The section of the rails shall conform to the design specified by the purchaser subject to the tolerances on dimensions prescribed by the purchaser.

Verification of tolerances shall be made with the gages or with other gages, as agreed by purchaser and manufacturer.

Rail Head Profile (1990)

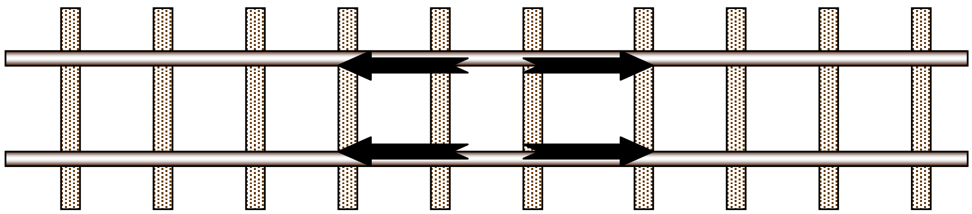


Transverse a cross- sectional geometry of the rail head extending from one bottom fillet radius to the other bottom fillet radius of the railhead.

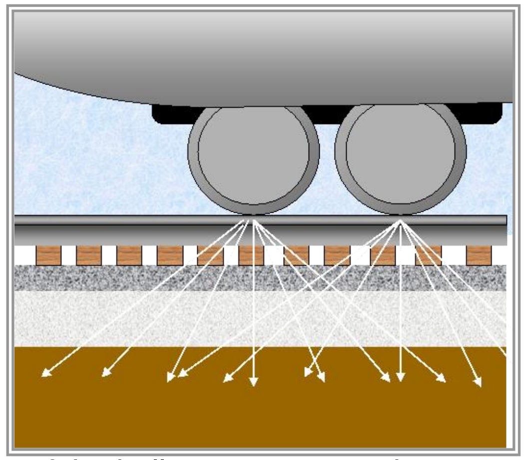
B. Load Transfer

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

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



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.

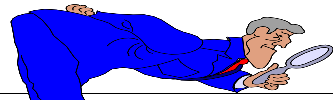
Just as the unit weight of rail has tended to become heavier over the years, so have rails tended to become longer.

Rail Joints

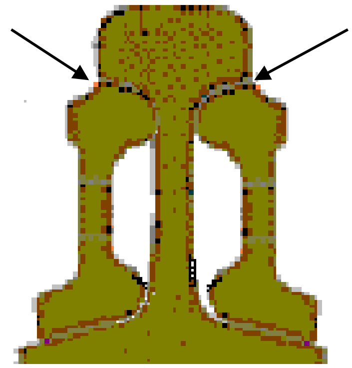
1. Ordinary Rail Joints

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.

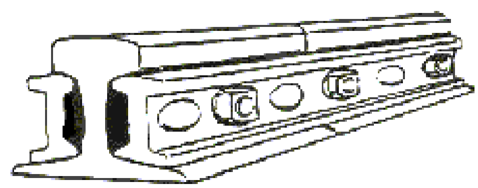


Here at MARTA we use only the Head Contact type of joint bar.

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.

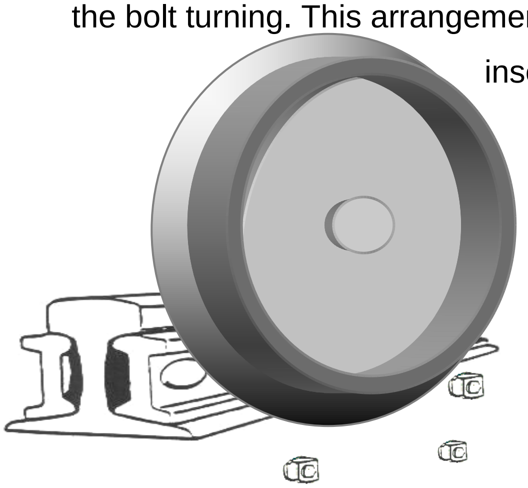
- The joint bars usually have alternate holes, which are oval in shape; the intermediate holes are round.

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.

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

2. Insulated Joints

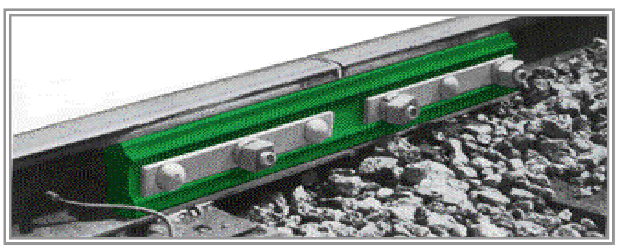
Insulated joint is electrically insulating one rail from the next.

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.



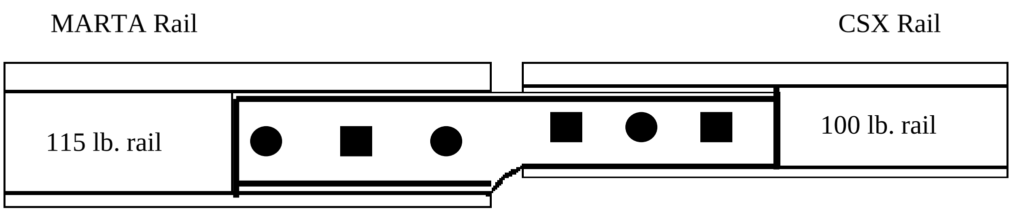
- Otherwise, these stresses would have to be carried by the track bolts.
- There are several designs of these adhesive type, or glued joints that have gained widespread use.

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.

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 CSX 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 lubricated 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 neither expand or contract. Allowing for the rail joint to be dismantled without the rail moving.

If 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.

1. If the rail joints do not close at a rail temperature 40°F above the Preferred Rail Laying Temperature (PRLT), the matter should be brought to the Foreperson or Managers attention. Where they will arrange to take any necessary action.

One method to relieve the problem would be to loosen the bolts and slacken 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.

- If the gaps do not close, de-stressing the rail is called for.

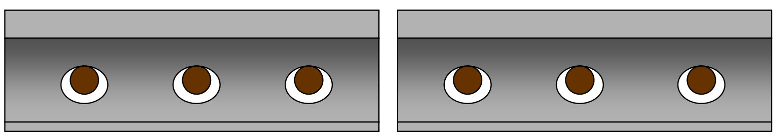
Rail joints other than Bonded Insulated Joints are not recommended in concrete tie territory, except as a temporary measure when repairing breaks or buckles.

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.

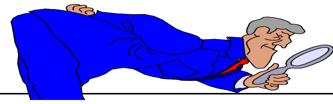
a) This provides for the expansion and contraction of rail in which stresses are to be relieved as the temperature changes.
b) Bolt holes in the rail are usually oversized in relation to the diameter of the track bolts in order to permit such movement.



c) 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 later.

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 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.

Sliding Rail Joint

The sliding joint is designed to take care of the expansion and contraction problems associated with Continuously Welded Rail.

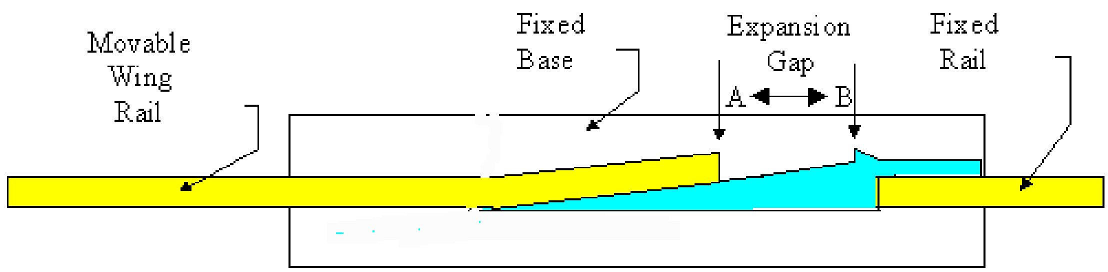
Expansion and contraction within the unit is permitted by simply allowing the wing rail to move back and forth.

The base (approximately 2400 pounds) provides a solid foundation for the sliding wing rail.

Maintenance Requirements:

- Ensure the wing rail is free to move (remove foreign matter from within the slide area)
- Check and tighten all braces and bolts, especially on open deck bridges
- Ensure the lag bolts have not broken off, if so, replace and tighten
- Check and maintain appropriate expansion gap in accordance with the following expansion gap table.

This type of rail joint can be found on the **YA track.** The YA track is located between the Airport Station and the South Yard. This type of joint relieves the stresses that are placed on the rail and the aerial structure.



SLIDING JOINT

Expansion Gap Table

Rail Temp °F	Distance from A to B in Inches											
0	16½	16¾	17⅛	17½	17⅞	18¼	18⅝	19	19⅜	19 ¾	20⅛	20⅜
10	16⅛	16⅜	16¾	17	17¼	17½	17⅞	18⅛	18⅜	18⅝	19	19⅛
20	15¾	16	16¼	16⅜	16⅝	16¾	17	17¼	17⅜	17⅝	17⅞	18
30	15½	15⅝	15¾	15⅞	16	16	16 ¼	16⅜	16 ½	16⅝	16 ¾	16 ¾
40	15⅛	15¼	15¼	15¼	15⅜	15⅜	15⅜	15 ½	15 ½	15 ½	15⅝	15⅝
50	14⅞	14¾	14¾	14¾	14⅝	14⅝	14 ½	14 ½	14 ½	14 ½	14 ½	14⅜
60	14½	14⅜	14⅛	14⅛	14	13⅞	13 ¾	13⅝	13 ½	13⅜	13⅜	13 ¼
70	14¼	14	13⅝	13⅜	13⅜	13¼	13	12 ¾	12⅝	12⅜	12⅛	12
80	13⅞	13⅝	13	13	12¾	12½	12⅛	11⅞	11⅝	11⅜	11	10⅞
90	13½	13¼	12½	12½	12⅛	11¾	11⅜	11	10⅝	10 ¼	9⅞	9⅝
100	13¼	12¾	11⅞	11⅞	11½	11	10⅝	10⅛	9¾	9¼	8¾	8½
	Length of Unanchored CWR in Feet											
	400	**500**	**600**	**700**	**800**	**900**	**1000**	**1100**	**1200**	**1300**	**1400**	**1500**

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.)

Continuous Welded Rail

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.

Continuous Welded Rail (CWR);

Each track constructed of Continuous Welded Rail (CWR) shall have in effect and comply with written procedures which address the installation, adjustment, maintenance and inspection of CWR.

Each plan for compliance with the following --

(a) Procedures for the installation and adjustment of CWR which include --

  (1) Designation of a desired rail installation temperature range for the geographic area in which the CWR is located; and

  (2) De-stressing procedures/methods which address proper attainment of the desired rail installation temperature range when adjusting CWR.

(b) Rail anchoring or fastening requirements that will provide sufficient restraint to limit longitudinal rail and crosstie movement to the extent practical, and specifically addressing CWR rail anchoring or fastening patterns on bridges, bridge approaches, and at other locations where possible longitudinal rail and crosstie movement associated with normally expected train-induced forces, is restricted.

(c) Procedures which specifically address maintaining a desired rail installation temperature range during repairs and adjustments. Rail repair practices must take into consideration temperature so that --

(1) When rail is removed, the length installed shall be determined by taking into consideration the existing rail temperature and the desired rail installation temperature range; and

(2) Under no circumstances should rail be added when the temperature is below (a)(1), without provisions for later adjustment

(d) Procedures which address the monitoring of CWR in curved track for inward shifts as a result of disturbed track.

(e) Procedures which control train speed on CWR track when

(1) Maintenance work, track rehabilitation, track construction, or any other event occurs which disturbs the roadbed or ballast section and reduces the lateral and/or longitudinal resistance of the track; and

(2) In formulating this above, the track owner must --

(i) Determine track stabilization procedures (speed restrictions, ballast consolidation, etc.); and

(ii) Take into consideration the type of crossties used.

(f) Procedures, which prescribe when track inspections are to be performed to detect buckling prone conditions in CWR track. At a minimum, these procedures shall address inspections to identify --

(1) Locations where tight or kinky rail conditions are likely to occur;

(2) Locations where track work of the nature described in (e)(1) have recently been performed; and

(3) In formulating the procedures under this paragraph, the track owner shall -

(i) Specify the timing of the inspection; and

(ii) Specify the appropriate remedial actions to be taken when buckling prone conditions are found.

(g) The track owner shall have in effect a comprehensive training program for the application of these written CWR procedures, with provisions for periodic re-training, for those individuals designated under 213.7 as qualified to supervise the installation, adjustment, and maintenance of CWR track and to perform inspections of CWR track.

(h) The track owner shall prescribe record-keeping requirements necessary to provide an adequate history of track constructed with CWR. At a minimum, these records must include:

(1) Rail temperature, location and date of CWR installations. This record shall be retained for at least one year; and

(2) A record of any CWR installation or maintenance work that does not conform with the written procedures. Such record must include the location of the rail and be maintained until the CWR is brought into conformance with such procedures.

(i) As used in this section --

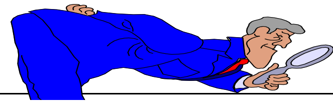
(1) **Adjusting/De-stressing** means the procedure by which a rail's temperature is re-adjusted to the desired value. It typically consists of cutting the rail and removing rail-anchoring devices, which provides for the necessary expansion and contraction, and then re-assembling the track.

(2) **Buckling Incident** means the formation of a lateral miss-alignment (sic) sufficient in magnitude to constitute a deviation from the Class 1 requirements specified in 213.55 of this part. These normally occur when rail temperatures are relatively high and are caused by high longitudinal compressive forces.

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

(4) **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. **MARTA P.R.L.T. is in tunnels 60° outside tunnels 80°**

(5) **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.



(6) **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.

(7) **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 (Pandrol clips) also act as rail anchors and control longitudinal rail movement by exerting a downward clamping force on the upper surface of the rail base.

(8) **Rail Temperature** means the temperature of the rail, measured with a rail thermometer.

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

(10) **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.

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

(12) **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.

Re-tightening Track Bolts

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

- 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.

In most cases, one re-tightening of the bolts will be sufficient, as the joint bars will have become fully seated by the traffic prior to the re-tightening.

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

Lining

Lining should be carried out at temperatures within the Working Zone. Working Zone is a temperature range of 10° + or - from the P.R.L.T. of 60° in the tunnels and 80° outside tunnles.

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

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

$$= 1.4 \text{ inches}$$

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

Where: ΔT = change in Force Free Temperature

α = Coefficient of thermal expansion of rail

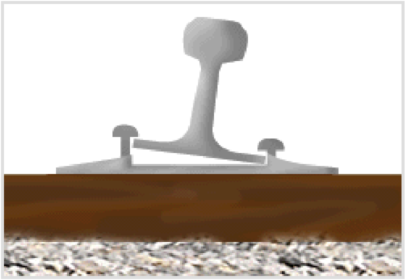
$\Delta T = 1.4(1000*12*0.0000067) = 17.4^{o}$ F

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.

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

Look for these Rail Indicators,

Canting on tie plates especially where small plates are used.

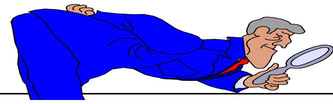


Crowding the shoulder of the tie plates on curves riding up or out of the tie plates.

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

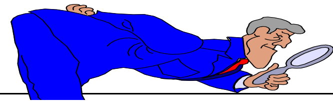
(e) Loose and shifted Pandrol Clips

(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° F above the PRLT.

(d) Buckles.

(e) Irregular gauge.

Ballast Section

Look for:

(a) Churned ballast.

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

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° F above, nor more than 10° F below, the **Preferred Rail Laying Temperature (PRLT).**

- This range of temperature is known as the preferred rail laying temperature range (PRLTR).
- **The PRLT at MARTA is 60° inside tunnels and 80° F outside of 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

- Ballast cleaning
- 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:

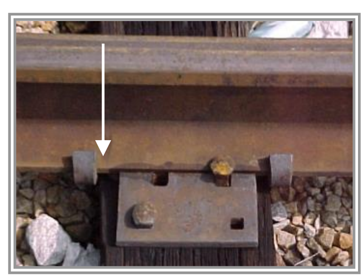
- Rail breaks
- Rail replacement
- Emergency brake applications
- Worn or defective anchors or Pandrol clips
- Poor quality or insufficient ballast
- Soft sub-grade.

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.

➢ **LOOK FOR THE FOLLOWING:**

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



(b) Pandrol clips or rail 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 a hi-rail access.

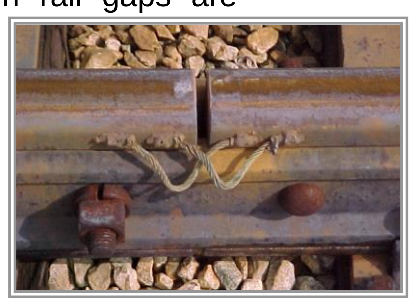
(h) Areas where renewal programs or surfacing has disturbed the track structure. In such areas ensure the slow order extends beyond the disturbed track to prevent brake application on the disturbed track.

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

- 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 marsh where the rail moves excessively under traffic causing ties to skew and bunch up.

(1) 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 of rail may be done by such means as:

(a) Atmospheric temperature

(b) Rail 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 pads of unanchored ties on both sides of the point where the adjustment is to be made.

(c) Properly adjust and install any sprung or missing Pandrol clips if necessary for all ties for at least 200 feet on each side of where the rail is to be cut.

(d) 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 are:

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 seat 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.

E. 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 45^{o}F and the PRLT for your territory is 80^{o} F. The temperature difference is $80^{o}-45^{o}=35^{o}$.

- Find the 1000 foot row on the left column
- Follow the row along to the column above the 35^{o} -temperature difference reading.
- Where the row and column intersect the reading is 2-7/8".
- This is the amount of rail expansion needed in order to properly distress the rail to 80^{o}F.
- 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.

F. Effects of Temperature Changes on Jointed Rail

Kinked or Buckled Track

The subject of rail **kinks** or **buckling** because of compressive stresses within the rails will be considered.

Things that happen to rails while they are in service that cause excessive stress with temperature changes will be examined.

Conditions related to jointed rail will be considered first.

When jointed rail is installed in track, small gaps are left between the ends of all adjoining rails, unless the rail temperature at the joint is close to the upper end of the range that is encountered in the area.

- The colder the rail temperature is, the larger the rail gaps in joints should be.

After rail is installed, rail anchors are installed within the limits of the rail yards.

- These rail anchors are principally intended to prevent the rail from running longitudinally, due to the effects of rail traffic.
- With Pandrol clips, rail anchors are unnecessary, Pandrol clips act as their own spikes and anchors.

As rail becomes alternately warmer and colder because of weather conditions, the rail expands and contracts. The gaps between the rails become smaller or larger.

This is based on the assumption that the rails will be free to slide back and forth, a short distance within the joint bars.

Therefore, when rail is laid, a lubricant will be applied to the surfaces where the rail ends and joint bars will be in contact with each other to facilitate this movement.

- Holes drilled in the rail ends are oversized in comparison to the diameter of the track bolts to permit such movement.

With this system it is intended that the rail will expand and contract freely with changes in temperature relieving any compressive or tensile stresses that might develop if the rail is restrained.

- At times, this system does not work as it is intended.
- It is essential that Track personnel understand how to detect problems of this sort as they are developing and how to correct them.

Rail Creep

Rail tries to lengthen or creep as its temperature increases, 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 sometimes referred to as anti-creepers.
- 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 longitudinal movement under traffic.

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

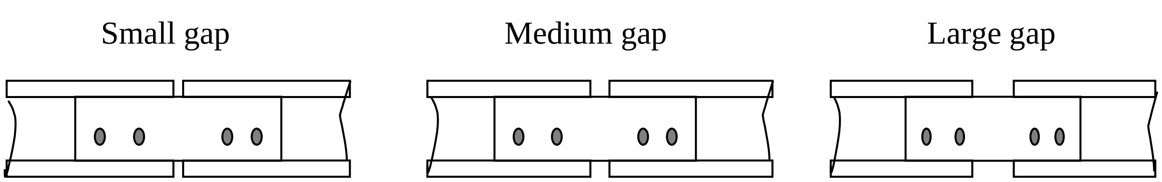
With single direction traffic as in multiple track main lines, this will not frequently be in the direction in which the traffic moves. Where the traffic movements are fairly well balanced in both directions, the predominant tendency will be towards the bottom of opposing grades and away from the crest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

G. 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.



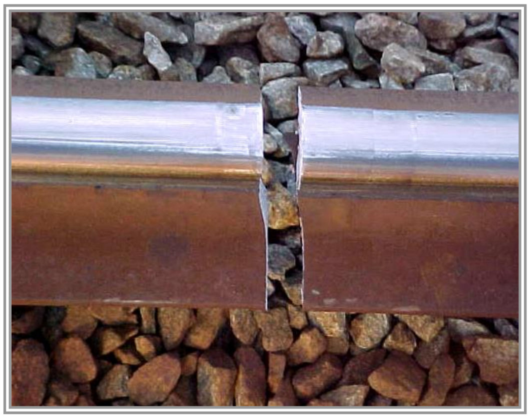
If the weather turns colder, the rail contracts, and small gaps reappear between the rail ends. The rail still tends to run together, and soon these rail end gaps close up.

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.

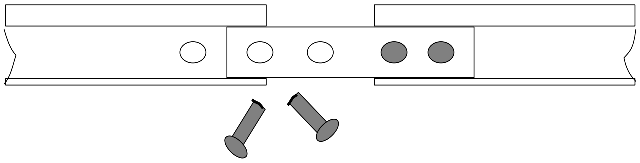
While the rail has been moving in one direction, and closing up rail end gaps in one area, somewhere back in the opposite direction, the rail end gaps have been increasing.

- 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.

In other situations, they lead to significant interruptions in traffic.

H. 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 re-applied 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 Pandrol clip or rail anchor slippage can be seen on the base of the rail.
- Corrosion of the rail base can also cause the Pandrol clips to become loose.

In most cases, Pandrol clip or 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 loose 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.

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

- Applying additional rail anchors or replacing 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" ASAP.**
- 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.

- If single shoulder plates are used, the gauge side rail holding spikes can also cause this marking. If slipping anchors are present, they will leave marks on the rail base.
- This is also true for Pandrol clips. If the rail has moved or is running, scrape marks will be seen on the rail base in the direction that the rail is moving.

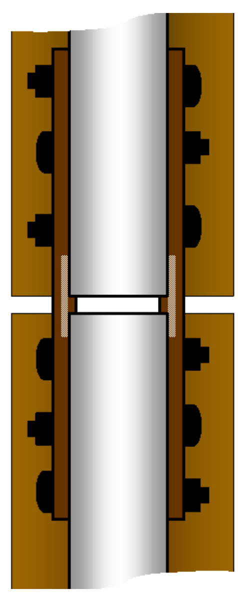
Frozen joints

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. A series of frozen joints creates a condition similar to CWR. Usually, there are not enough rail anchors present in jointed rail to provide the protection that anchors provide for CWR.



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 track work begins. The cool temperatures at night will allow the rails to loose 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, then it is reasonable to presume that excessive rail compression is unlikely.

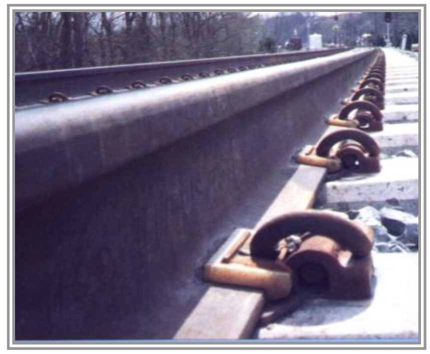
If there is a substantial number of joints where the tops of joint bars are rusty before the sun has heated the rail, further check for frozen joints should be made.

- Try loosening the bolts in a joint enough to relieve the bolt tension, then loosen the joint bars.

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.

I. Effects of Temperature Changes on CWR



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

Once CWR is installed, it is designed so 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 here in the rail yards or could mean Pandrol clips on the mainline track which perform the same function as standard rail anchors.

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 80˚ F outside tunnels and 60˚ F 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.

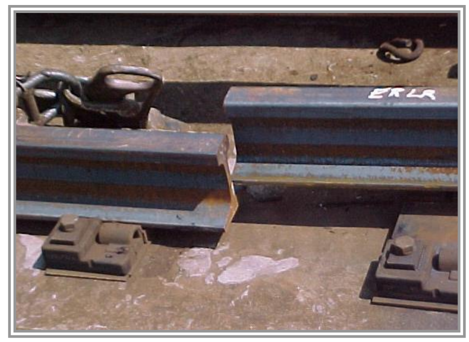
- This is done because it is felt that the track can withstand higher stresses in tension at cooler temperatures than in compression at hotter temperatures.

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.

Adjusting CWR

To adjust the rail, remove the joints at the ends of the strings of CWR.

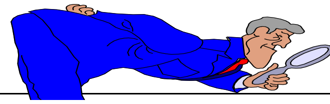


If the rail was laid at a cooler temperature,

1) Misalign the ends of the string so that when it expands the two rail ends don't run into each other.
2) Remove all rail anchors, where applicable.
3) The friction between the rail and the tie plates and spikes must be eased.
4) If on concrete ties or direct fixation, remove Pandrol clips.
5) The rail can be moved with a rail vibrator or by tapping or prying the rail at frequent intervals.
6) The rail anchors should then be reapplied.
7) If on concrete ties or direct fixation, replace the Pandrol clips.
8) Necessary adjustment at the rail ends is made by cutting to secure the proper length of rail.

If the rail was laid at a temperature above the specified rail laying temperature, then;

1) Rail will have to be added when adjusting.
2) Remove all rail anchors if applicable.



3) The friction between the rail and the tie plates and spikes must be eased.
4) If on concrete ties or direct fixation, remove Pandrol clips.
5) The rail can be moved with a rail vibrator or by tapping or prying the rail at frequent intervals.
6) The rail anchors should then be reapplied.
7) If on concrete ties, replace the Pandrol clips.
8) Joint bars are then reapplied or the rails are field welded.

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, additional rail anchors or 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.

Remember, Never overdrive a Pandrol Clip

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.

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 from first the MARTA Track Safety Standards, for track alignment.

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.

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.

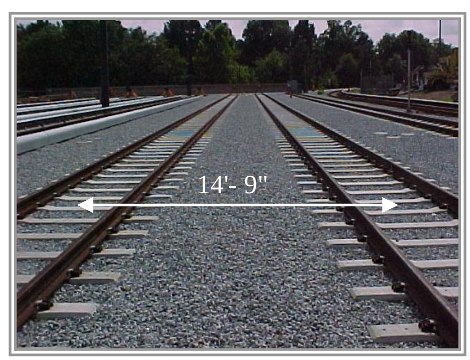
Unless the rail temperature has dropped significantly since the track buckled, this will probably be difficult. Furthermore, the track will tend to be unstable, and likely to buckle again.

- The Ballast Consolidator may aid in settling the track after it has been re-laid.

If it is important to keep the track in a condition that will permit operation of trains even at slow 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 track side structures or earthwork, or a close track center condition with an adjacent track.



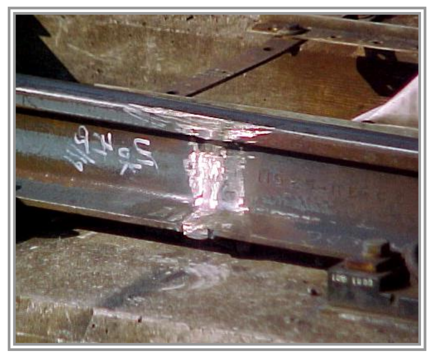
- **MARTA track centers are a minimum distance of 14 feet 9 inches.**

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.

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 rail than is necessary to correct the condition.
- **If the rails must be stretched to rejoin them, pull a-parts may be likely in cold weather:**

After the rails are cut and connected, rail anchors need to be reset or rail clips 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 sever 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.

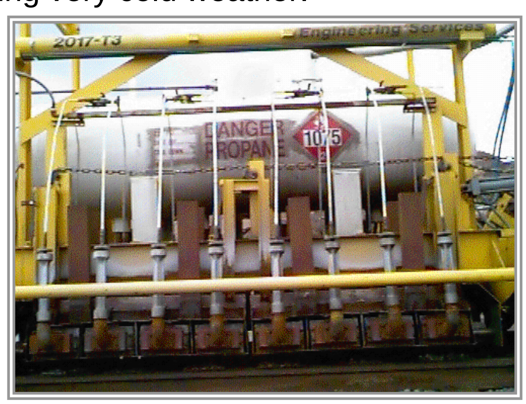
- The rail may have to be replaced in accordance with MARTA Track safety Standards.

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

- **Verify the company's standards from the MARTA Track Inspection Manual.**

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.

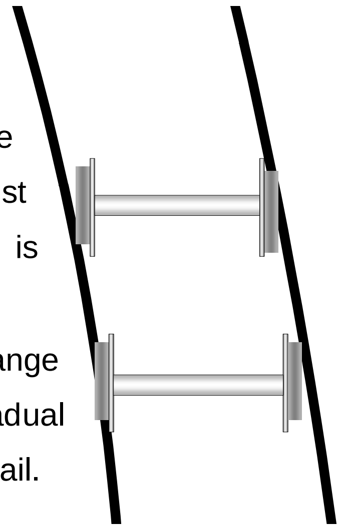
- Heating the rail could then close the remaining, balance of the gap.
- A rail heater, as is shown in the picture, will work, so too will the manual way to heat rail by using rope soaked in diesel fuel and lit.

After the rails are bolted together, the Pandrol clips will have to be reinstalled.

- Consideration should be given to applying additional anchors for protection on the side of the ties affected by rail in tension.
- 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.

J. Curve-worn Rail



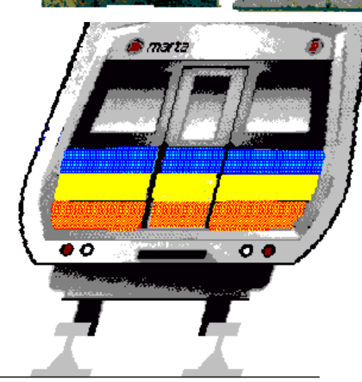
It has been shown that as trains travel around a curve, the lead wheel of each truck on the high or outer rail must constantly be deflected from the straight line path it is attempting to follow.

- This constant abrasive action between the wheel flange and the gauge side of the railhead 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 railhead might be carried on until too much of the railhead 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 rail, but much of it can be caused by the rail wear.

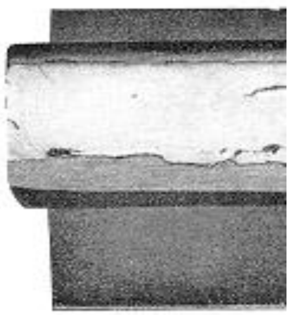
Curves must be elevated on the outer rail to protect trains moving at the maximum authorized speed.



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

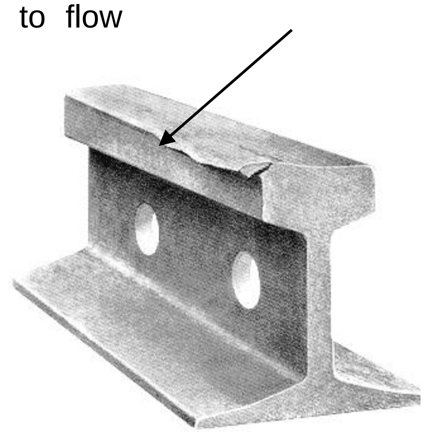
- When trains operate at these much slower speeds, a good deal more than half of the axle weight may be placed on the low or inner rail because of the car being tilted to that side by the elevation.

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 railhead and tend to be large.



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

There is also a tendency for the steel to flow outward, beyond the edge of the railhead 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.

K. Prolonging Rail Life

On many curves, particularly sharper curves, it is these conditions which shorten the 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. (Heat-treated or Head hardened rails)
- 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 railhead friction.

The most common type is attached to the rail ahead of 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 railhead.

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.

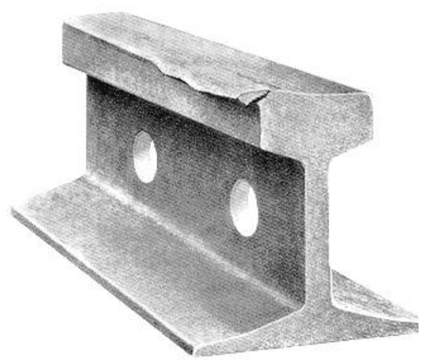
The gauge side of the former high rail is now the field side of the low rail. The gauge side of the former low rail is now the field side of the high rail.

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 railhead 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.

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.

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 railhead wear on a curve to the point where track gauge is at the maximum limit and the low side rail is unsuitable for transposing.

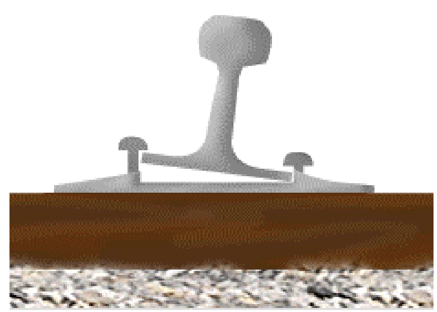
L. Correcting Wide Gauge

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

Gauge widening to the extent that correction must be made usually occurs on curves.

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



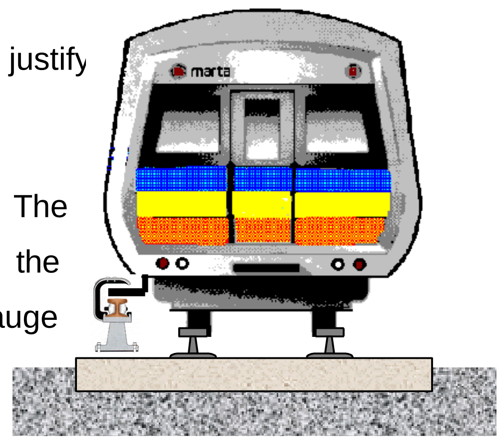
In many cases where spreading or canting occur they develop at a slow enough rate to permit correction during the rail replacement process.

- 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 railhead 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 for a class 4 track.

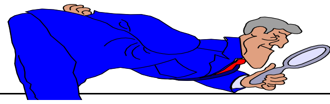
- It is decided to re-spike, re-lag or re-anchor the rail and tie pads or plates to correct the gauge. Or to correct the gauge by adjusting the pads themselves.

Maximum MARTA track gauge is 57 ¾"

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.

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



- This will leave the gauge wider than the 56-1/2 inches standard but still within the MARTA 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.

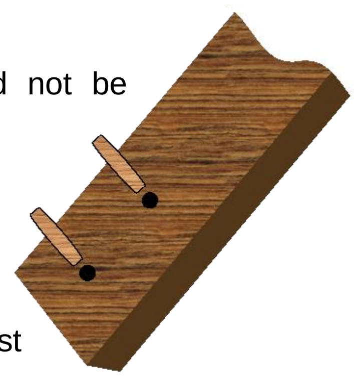
This means that the track will end up with the alignment of the undisturbed rail.

- 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.

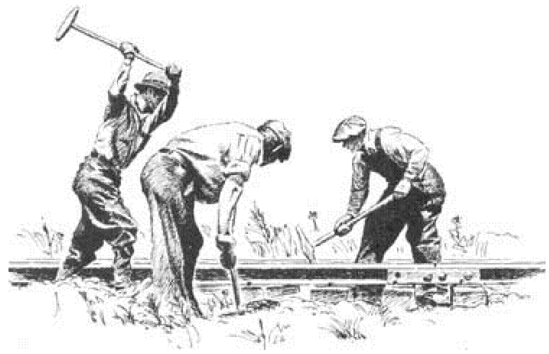
It is necessary to line the rail out of the way to provide clearance for the following operations.

- 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 to rest on.

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.



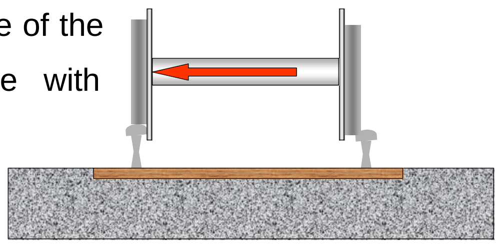
- This method lends itself to a high degree of mechanization.
- The amount of equipment actually used will, of course, depend on availability.

M. Effects of Truck Hunting on Tangents

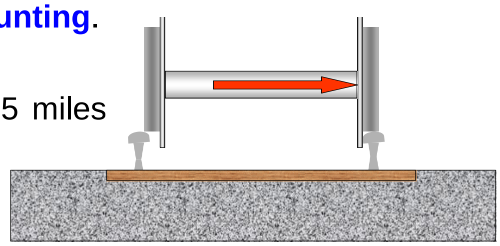
Although the need for gauging is predominately on curves, the need for performing gauging work on tangents is increasing.

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.

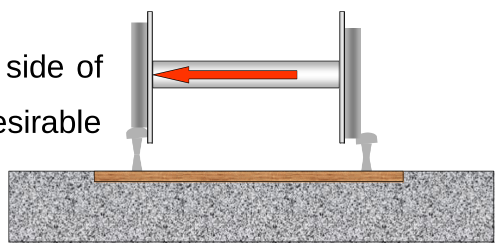


This rotation can continually reverse itself at a fairly high frequency, and it is known as **truck hunting**.



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 railhead tend to create the usual undesirable conditions:



- Gauge widening

- Loosening of track fasteners
- Rail canting
- Wear on the gauge side of the railhead

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 railhead surface
4. Lateral pad movement
5. Stress cracks around the shoulder castings on concrete ties

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 rail grinder passes over the track at slow speeds, grinding the railheads 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.

Appendix

Rail Laying and De-stressing

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 procedure will cover:

1. Moving New CWR from storage locations 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.

This procedure does not include procedures required for MARTA Flag Personnel, ATC or EP&E personnel for readying the track for rail replacement or back into revenue service.

Rail Replacement Procedure

Equipment & Material

2-Pettibone Speedswings

16-Mini-Rail Train Carts, 4-Carts with air operated brakes, Geismar Model CWR Rail Train

2-Hi-rail Stakebody Trucks

1-Rail Vibrator

1-Hydraulic Rail Puller

4-Rail Carts for Scrap Rail Loading, Part of Mini Rail Train Carts with Air Operated Brakes.

115# Thermite Weld Kits

115# Rail Joints

Aerial Structures

Prep work Mainline

The first part of the outage will be utilized to:

- Setup protection fencing and toe boards if required on aerial structures to protect from objects falling below.

String line the low rail of the curve and record data for reinstallation of rail and final adjustment.

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

- Remove Impedance Bonds, cables and other 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.

Remove Gauge Rods

No pre-cutting of the rail will take place until the replacement rail is in the work area.

- Check over the rail train for safety and readiness to make move to mainline.

Move rail train to work area via mainline track traveling from yard location.

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.

- All Rails needed for changing the High side & Low side will be unloaded 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.

- 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 opposite the Third Rail.

When the removal of Pandrol clips has progressed from the starting point the 1st 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 1st 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 2nd Pettibone by picking up the new rail and placing it into the fasteners.

Once a sufficient amount of rail has been set into the Fasteners every 8th 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 8th clip installed, the Thermite Weld or Rail Joint will be made at the starting point.

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

Following the completion of the second CWR string, a second Thermite weld or Rail Joint 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 down hill.

When both welds have been completed rail stressing will begin.

Adjusting and Anchoring Rail

Overview –Anticipate the ambient temperatures to be sufficient for rail movement if the rail replacement is being completed during the spring and summers months. On the other hand, if rail replacement takes place in the fall and winter months some rail expansion must take place, 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 or Joint, 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, 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 Thermite welding or Standard Jointing.

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 or Standard Joint.

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 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 or joints have been completed rail stressing will begin, refer to the Adjust and Anchoring Rail Section previously discussed.

Insulated Rail Joints

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 Thermite welding in the Insulated Joint Plug.

Rail Clean Up and Removal

Upon completing the rail adjusting and anchoring of the High rail, the Pettibone will begin to pickup all rails removed from the rail replacement process.

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 and or pad 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.

Subways, Floating Slab, and Ballasted Track Sections

The process for changing rail in Subways, Floating Slabs and Ballasted Track Sections is the same as stated above for Aerials, with the exception that both rails can be changed at the same time in these areas. On Aerial structures, one rail has to be tied down at all times to ensure structural stability.

Prep work Mainline

The first part of the outage will be utilized to:

- String line the low rail of the curve and record data for reinstallation of rail and final adjustment.
- Identify exact limits of rail replacement with PBT Inspectors 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.
- Remove Gauge Rods if installed

No pre-cutting of the rail will take place prior to the positioning of the replacement rail.

Begin Rail Replacement

New Rail will be placed inside the gage of the track on top of 4x4's spanning the second pour. This will aid in the rail replacement, the base of the new rail will be higher than the existing DF

Once the rail has been unloaded, the Pettibone cranes will be switched around if required.

While the Pettibones are in the process of switching, begin saw cutting both the High & Low Rails at their starting point and begin removing the Pandrol clips.

When the removal of Pandrol clips has progressed from the starting point the Pettibone will begin removing the old rail from both High and Low side 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 for the remainder of the way through the curve until all rail scheduled for replacement has been moved.
- The last transition joint where the new rail meets the existing rail will be saw cut once the Pettibone has reached this point. If the transition joint is not the final ending point of rail replacement, a bolted temporary joint will be made utilizing the two outside holes on both rails High & Low sides.
- 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 by picking the new rail and placing it into the fasteners.

- Once a sufficient amount of rail has been set into the Fasteners every 8th 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.

When the first CWR stings have been fully placed into the DF Fasteners and every 8th clip installed, the Thermite Welds or Standard Joints will be made at the starting points.

- 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 Thermite weld or Standard Joint 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 substantial vertical grade then the low point joint will be left open for stressing of rail downhill.

EXHIBIT

MARTA TRACKWORK — PROJECT NO. CPB 2480

RAIL ANCHORING REPORT

DATE: REPORT NO.:

WEATHER CONDITION AT START: WEATHER CONDITION AT FINISH:

TRACK DESIGNATION: RAIL: LEFT OR RIGHT

RAIL TEMP. BEFORE APPLYING HEAT: BEGINNING MEASURED RAIL LENGTH (FT): __

EXISTING RAIL GAP (NEAREST 1/16 INCH): 0.000078 = RAIL LENGTH = (DESTRESSING TEMP. RANGE- ACTUAL TEMP.) MOVE1iENL

FINAL TOTAL RAIL LENGTH CALCULATIONS:

	TYPE OF RAIL	**START**			FINISH				
TRACK LIMITS STA'T'ION TO STATION	ADJUSTMENT 1-TEAT & VIBRATE OR VIBRATE ONLY	TIME	AIR TEMP.	RAIL TEMP.	TIME *	AIR TEMP .	ACTUAL RAIL TEMP.	RAIL-END MOVEMENT *	LOCATION TUNNEL OR ELSEWHERE
TOTAL RAIL MOVEMENT									

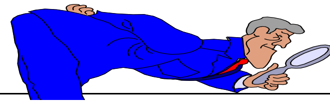
RECORDER: WITNESSED

CONTRACTOR'S REPRESENTATIVE & TITLE AUTHORITY'S REPRESENTATIVE & TITLE

02XS-16 REV. 3-2-95
C.D., III

*Include end movement of CWR recorded either at 30-minute intervals or at 200-foot lengths of track when rail is being anchored.

CP B2480 - 0245



Contact Rail (3rd Rail) Standards

Contact(3rd) Rail

Third rail anchors must be checked to see that they are properly anchored to the ties, bridge or aerial structure pedestal and that all 3rd rail anchor rod (arms) are securely fastened to the anchor support and to the third rail itself. Make sure all bolts, nuts and cotter pins are tight and in their proper place.

Inspection of 3rd Rail Insulators

Insulators should be checked for cracks, breaks and any misalignment that may occur due to temperature changes or equipment striking the 3rd rail.

- Any defects found in the 3rd rail insulators must be reported immediately.

The insulators should be kept clean of metal shavings and brake dust to prevent excessive leakage of third rail current.

- If three non-supporting insulators are found in a row, train operations over that third rail shall be limited to 10 mph and replacement scheduled.
- If five or more non-supporting insulators are found in a row, all train operations over the effected area must be supervised until the condition is corrected.

Insulator assemblies must be considered defective if they are no longer able to support the 3rd rail to its proper position.

- If the displacement of the 3rd rail occurs examine to see if insulators are cracked, broken or missing.
- If displacement exceeds ¾ inch for alignment or surface on mainline track or ½ inch inside tunnels, speed should be reduced to 10 mph immediately.
- Third rail insulators should be inspected for signs of tipping.
- Check the placement of the third rail in the insulator cap to observe any rail movement.

Third rail must be kept in its correct position so that its height and distance from the running rail is within limits of tolerances previously referred to.

Expansion Joints

Expansion joints must be inspected to see that the third rail moves freely within that expansion joint to allow for the expansion and contraction that occurs due to temperature changes.

- This thermal expansion and contraction can be aided by having the third rail expansion joint lubricated with grease.

Power cables should be checked to ensure proper connection and all bolts, nuts and cotter pins inspected. Any bolt that is broken, nut loose or missing or cotter pin broken or missing needs to be reported immediately for repairs.

marta

A Standard Of Excellence

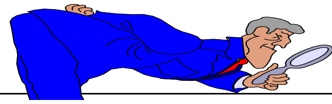
Technical Training

Track & Structures

Track Inspection Training

Rail Joints

Section 6



Rail Joints

For many years rail joints were considered to be a necessary part of the track structure. Little effort was made to develop reliable means of welding rail into continuous strings. The overall view was that rail joints were necessary to permit rail to expand and contract with temperature changes.

Few people realized the ability of the track structure to adequately restrain rail and to prevent expansion and contraction.

There was a theory that if the rails were subject to appreciable thermal stresses, the track would be highly unstable, and considered unsafe for the operation of trains.

It has long been recognized that rail joints are expensive to maintain.

- They have frequently been referred to as the weakest link in the track structure. This is because of their inability to retain the same stiffness as a regular section of rail.

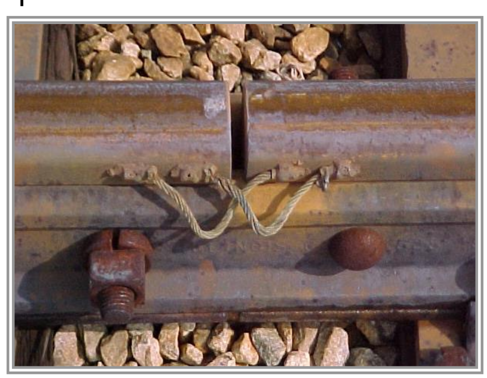
A. Modern Rail Joints

1. Rail Joints

Modern rail joints are designed with considerable strength. Over the life span of the rail, rail joints will require a considerable amount of maintenance.

- It is when this maintenance is neglected, and the rail joint is allowed to deteriorate, that it frequently becomes a weak spot.

There are several types of maintenance that may be required by rail joints at various times. Neglect of just one type of maintenance can cause other defects to develop within a joint, which in turn will necessitate additional types of maintenance work.



Because of the relationships that exist between various phases of joint maintenance and the significant part which rail joints play in the total track maintenance effort, this entire module will be dedicated to the subject of rail joints.

During periods of very warm weather, when adjoining rail ends will normally be contacting each other, every wheel which passes over a rail joint will have to bridge an open gap between rail ends.

- These openings are usually quite small. Under extreme conditions, they should not be more than about 1/4 inch.

Steel railcar wheels are quite inflexible and when the car is fully loaded, the wheels carry very heavy loads.

- This creates an impact stress or pounding effect as the wheels move over the gap between rail ends.
- Just like walking down a flight of stairs, the impact is always on the next step not on the step that your foot is leaving.

This pounding is directed to the rail end that the wheel is moving toward, rather than the rail end it is moving from.

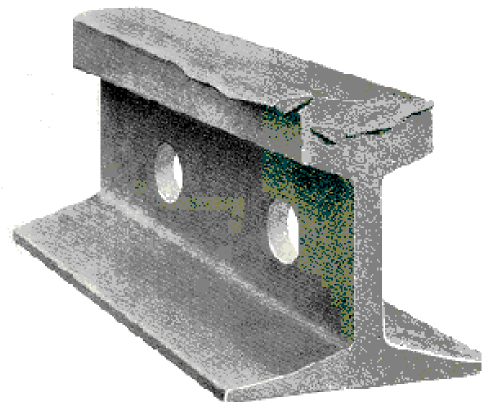
These rail ends within a joint are known as the **receiving end** and the **leaving end**, respectively, in relationship to the direction of travel.

2. Rail End Batter

This pounding effect on the receiving-end of the rail causes the steel to become deformed or battered over a period of time.

- As batter develops, this irregularity in the running surface of the rail causes the pounding to become more severe. As the pounding of the wheels becomes more severe, the extent of the batter becomes worse. The process tends to become self-destructive.

If rail traffic is predominately in one direction, (as is the practice here at MARTA) and the same rail end is almost always the receiving end, this will be evident in the way in which rail end batter develops.



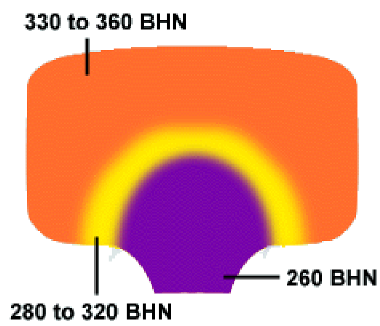
However, if the traffic is evenly distributed as to direction, as in a single-track operation, a different pattern of rail end batter will develop. Both rail ends in a joint will develop batter.

Every wheel moving across the rail joint will be moving downward before it gets to the rail end gap because of the batter on the leaving-end.

- This further increases the pounding effect that can be anticipated.

Rail end batter develops relatively slowly. There are various conditions that can contribute to this development in addition to the movement of wheels across the rail end gap.

These conditions, as well as measures that can control rail end batter will be considered throughout this module.



3. Rail End Hardening

One of the procedures which are used to minimize rail end batter is end hardening of rail.

- This is usually done at the rail mill on new rails that are drilled for rail joints.
- It can also be done at the track when it is necessary to put a cut end into a joint.

The procedure consists of the rail being treating the first few inches of the rail at the end of the rail.

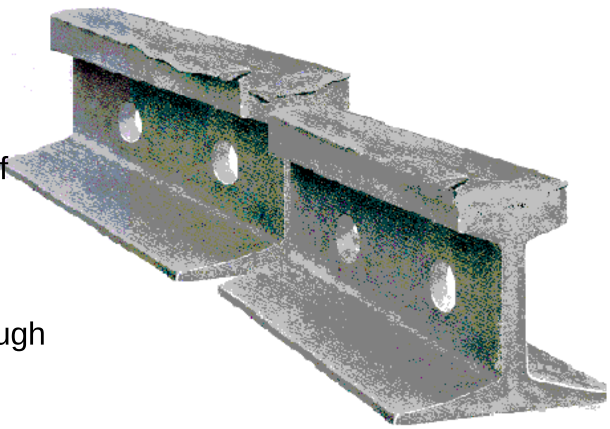
- End hardening can substantially reduce rail end batter, but under severe traffic conditions will not totally eliminate it.

At times under heavy traffic conditions, so-called secondary batter will develop on the rail within the limits of the joint bars beyond the area that was end hardened.

4. Need for Cross Grinding

The flattening of the running surface of the rail, which takes place with batter, consists primarily of flow of the steel, rather than a wearing away.

- One of the directions that this flowed metal may move is into the open rail end gap.



The tendency to form a lip within the rail end gap becomes troublesome with the coming of warm weather.

These rail end lips usually are not strong enough to prevent the expansion of the rail.

Rather, as the rails expand and the lips come into contact with the adjoining rail end, the lips tend to break off.

- This breakage or chipping usually extends back past the rail end.
  With this loss of metal on the running surface at the rail end, the gap which the wheels have to jump becomes considerably larger. With heavy traffic under such conditions, a joint can deteriorate rapidly.

Chipping out of the running surface of the rail end can be avoided. The recognized procedure is to grind off the flowed metal before chipping occur. There are special grinding machines used for this purpose.

It is recommended that when this type of grinding is performed, the rail should be ground to a distance of 1/16 inch in from the rail end and to a depth of 1/8 inch.

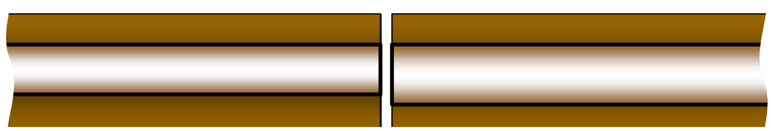
Care should be taken to avoid grinding back any greater distance from the rail end, as this has the effect of widening the rail end gap which wheels must bridge.

B. Rail End Mismatch

The pounding effect of wheels moving over a rail joint can also be increased by the mismatch of the rail ends within a joint.

- This mismatch can be in the form of a difference in the size of the tops of the rails.
- It may also be of the form of an offset between the gauge sides of the two rails.

Mismatch may be caused by the installation of adjoining rails with varying amounts of side or tread rail wear. It can also be present in worn or loose joints that do not hold the rail to proper surface and alignment.



Limits of mismatch are specified by the MARTA Track Safety Standards.

Rail Joints

Inspect all rail joints for loose or missing bolts. At least two (2) sound, tight bolts must be in each rail of each joint. If there is at least one, but less than two good bolts in either rail, then a 25 M.P.H. slow order must be placed in effect and Track and Structures Supervisory Personnel notified immediately. If there is not at least one good bolt in either rail, the track must be removed from service immediately. Insulated joints should be inspected and cleaned.

- Also advise of any overflow of the rail ends at the insulated joints, as this could short out the train control circuit. Also, all rail joints should be observed for the following.

Rail end batter: Any excessively battered rail ends should be noted and recorded. Batter must be measured with a 36" straight edge and taper gauge. All measurements should be recorded. Any measurement of 0.25" (1/4") or greater must be reported ASAP.

Rail joint gap: Any gap over 3/8" should be noted.

- Any gap over 5/8" notify ASAP. (Especially in cold weather).

Rail joint and weld stagger: Bolted joints, bonded joints, field welds, and shop welds must meet the minimum distances listed in the table below.

If the mismatch is caused by a loose or worn joint, the corrective action may consist of nothing more than the tightening or replacing the track bolts. It may also necessitate replacing the joint bars if they are excessively worn. For in some instances, replacement of worn joint bars may be necessary.

When mismatch is caused by differences in either side of the rail head or tread wear of the ends of adjoining rail, this condition is present at the time of rail installation.

This can occur when a single rail is installed to replace a defective rail.

- Mismatching can also result from laying a stretch of jointed relay rail, when the individual rails are not well separated by wear.

Careful selection of rails, according to wear, can do much to minimize the occurrence and severity of mismatch.

Inevitably, there will be situations where mismatched rail ends result from rail installation. Correction of mismatch is desirable, not only to conform to the MARTA Track Safety Standards, but also to reduce the pounding of railcar wheels which results from mismatch.

C. Rail Joint areas

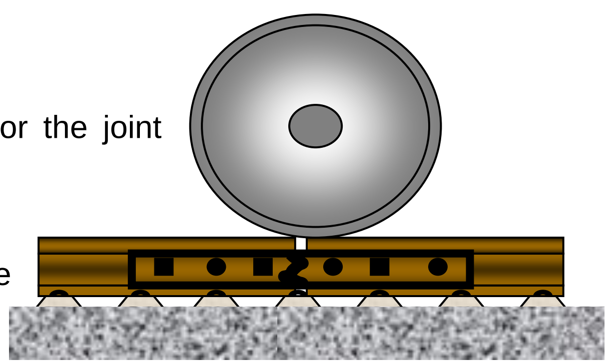
So far, this module has been directed towards the rail surfaces that come in contact with the wheels within the joint area. It has been shown that running surface conditions can result in additional stresses being impacted to the track structure by moving wheels of train equipment.

These impact stresses result from the pounding that takes place when wheels move over irregularities in the rail surface. Such stresses are in addition to those due to supporting the weight of the train.

1. Joint Bars

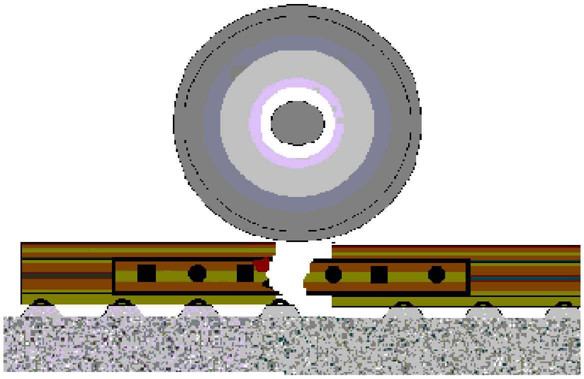
Joint bars need to be capable of supporting both the weight of the wheels which pass over the joint and the impact stresses caused by wheels striking irregularities in the rail surface. Also, if the rails are in tension because of low temperature or rail creep, the joint bars will likewise be in tension.

If these various types of loads are too great for the joint bars to support, the joint bars break.



Frequently the point of greatest stress is at the midpoint of the joint bars at the ends of the rails.

If both of the joint bars break completely through at this location, the effect is the same as having no joint bars.



When this happens there is considerable danger of the rail ends moving out of alignment relative to each other under load, and a derailment occurring.

Cracks or breaks in the joint bars sometimes develop in the vicinity of bolt holes. Such conditions are usually not as critical as breaks through the middle of the bars, but if such bars are left in track, the joint usually deteriorates rapidly.

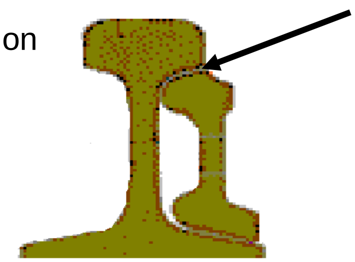
- There are MARTA standards which apply to broken, cracked or worn joint bars.

Joint bars may fail to satisfactorily support the rail ends in other ways, even if they do not crack or break.

- This contact, normally, extends the entire length of the joint bars.

The surfaces of the bars and rails which make contact with each other are known as **fishing surfaces**

- Firm and uniform contact is dependent upon proper tension within the track bolts.



When the bolts become loose, the contact between joint bars and rails is, no longer firm.

As wheels move over a joint, the rails and, joint bars no longer act as a unit.

There begins to be slippage between the contact surfaces.

- In time. this will cause wear on the contact surfaces of the rails and joint bars.

If the bolts are re-tightened after this happens uniform support will not be restored. The greatest wear will occur in the most critical area at the ends of the rails and the center of the joint bars.

Even before wear occurs, a loose joint causes other problems. The lack of stiffness allows the rails to depress excessively between the two joint ties.

- The irregular surface caused by this depression of the rail ends increases the pounding of wheels on the joint.

In addition to further loosening the joint bars, such pounding places excessive loads on the two joint ties.

- This can lead to rapid breakdown of the ballast support under those joint ties.

Excessive wear can develop on the joint ties, greatly shortening their life.

If the joint bars become loose under a supported joint, the center joint tie usually gets the brunt of the excessive loads first. In time, as this tie will deteriorate, or the ballast support under the tie fails, increasing loads are then passed on to the adjacent joint ties.

(a) Each rail joint, insulated joint, and compromise joint shall be of a structurally sound design and dimensions for the rail on which it is applied.

(b) If a joint bar on *Class 3 through 5 track is cracked, broken, or because of wear allows excessive vertical movement of either rail* when all *bolts are tight, it shall be replaced.*

(c) If a joint bar is cracked or broken between the middle two bolt holes it shall be replaced.

(d) In the case of conventional jointed track, each rail shall be bolted with at least two bolts at each joint in Class 2 through 5 track, and with at least one bolt in Class 1 track.

(e) In the case of continuous jointed track, each rail shall be bolted with at least two bolts at each joint in Class 2 through 5 track, and with at least one bolt in Class 1 track.

(f) Each joint bar shall be held in position by track bolts tightened to allow the joint bar to firmly support the abutting rail ends and allow longitudinal movement of the rail at the joint to accommodate expansion and contraction due to temperature variations. When no slip joint to rail contact exists by design, the requirements of this paragraph do not apply. Those locations when over 400 feet in length, are considered to be continuous welded rail track and shall meet all the requirements for continuous welded rail track prescribed in this part.

(g) No rail shall have a bolt hole which is torch cut or burned in Class 2 through 5 track. (For Class 2 track, this paragraph (g) is applicable September 21, 1999)

(h) No joint bar shall be reconfigured by torch cutting in Class 3 through 5 track.

5. Worn Fishing surfaces

Wear occurs on the surfaces of joint bars that make contact with the rails, as well as on the corresponding surfaces of the rails. The rate of wear can be greatly accelerated by loose joints, battered rail ends, excessive rail end gaps, soft joint ties and poorly surfaced joints.

Even in well-maintained joints, wear takes place on the fishing surfaces of the joint bars and the rails although at a much slower rate.

When wear in this area becomes severe enough to cause joint maintenance problems, consideration should be given to corrective measures.

- Some transits or railroads carry out programs of replacing worn joint bars. When this is done, the joint bars used in replacement may be sufficiently oversized in the worn areas to compensate for the corresponding wear on the fishing surfaces of the rails.

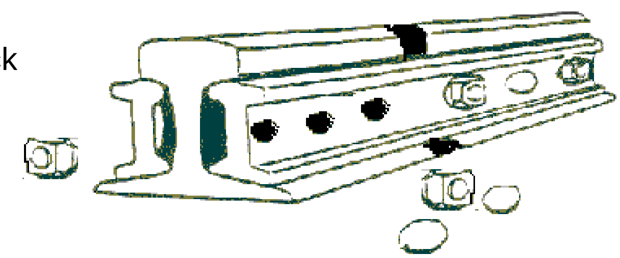
Such programs are most effective if carried out in combination with other needed joint maintenance operations.

If the rail ends are battered, a program of restoring them by welding may be justified. Frequently, either spot surfacing of the joint or a general track raise is desirable when the joint bars are replaced.

D. Bolt Maintenance

Track bolts must be tightened to a high stress in order to permit the joint bars to effectively support the rail ends. At the same time that the bolts are stretched in tension, they may be subjected to other stresses that are caused by the way the rail and joint bars tend to bend the bolts.

- Every wheel that passes over the joint causes flexing and vibrations that can add to the stresses in the bolts and cause loosening of the nut.



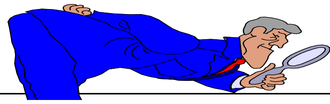
Considering the severe service that track bolts must perform, it is not surprising that bolts tend to loosen over a period of time.

- Also, track bolts occasionally, break as a result of the stresses placed upon them.

When new rail and new joint bars are installed. the track bolts tend to loosen rather quickly at first.

- This is due to the loss of mill scale from the fishing surfaces. This can be corrected by wire brushing the fishing surfaces of the joint bars before they are installed.

At times, it may take some flexing of the joint under traffic to fully seat the joins bars. Therefore, the initial tendency of bolts to loosen can occur with relay rail as well as with new rail.



1. Bolt Tightening

Whenever rail is installed, plans should be made for re-tightening the bolts. Under extremely heavy traffic, this need could be apparent in as short a span of time as a week.

Under normal conditions, several weeks may pass before bolt re-tightening is needed.

Once this initial step of bolt maintenance is completed, bolt loosening usually takes place at a much slower rate.

- If the joint is in good condition, loosening will take place at a fairly constant rate.

  Since this process is fairly slow the usual policy is to tighten bolts in a manner that will extend the intervals between re-tightening.

This is to maintain a proper fit between the joint bars and the rails:

It is necessary to have minimum tension of between 5,000 and 10,000 foot-pounds in each bolt.

- If bolts were tightened to this range the gradual loosening process would soon reduce the tension to a lower level. The joint would not be tight enough to provide adequate support.

The normal practice when re-tightening bolts is to bring the tension up to a range of 15,000 and 25,000 foot-pounds.

Under average conditions, it will take about a year for the bolt to loosen, to the extent that the tension is in the minimum range.

- This may be accelerated here at MARTA because of the frequency of rail traffic.

Normal practice for the initial tightening is in the minimum range.

Normal practice for the initial tightening of newly installed rail is for the tension to be brought to a somewhat higher level, in the range of 20,000 to 30,000 foot-pounds, since tension is lost so quickly.

Hand tightening is sometimes carried out on an extensive scale simply because bolt tightening equipment is not available. Bo1t tightening is one of the few track maintenance operations that can be effectively completed during winter weather.

Hand tightening of track bolts does not produce the same degree of tension that can be attained from machine tightening.

A good practice which should produce tension in the desired range is to tighten the nut on the bolt until it is 1/2 turn from the point where it cannot be turned any further.

- This procedure is for one person of average strength using an AREMA standard length track wrench.

There may be other situations where tightening of track bolts by hand is justified. These include:

1. Hand tightening location where the relative number of bolts requiring tightening does not justify the use of bolt tightening machinery.
2. Selective hand tightening during walking track inspections
3. Hand tightening to be accomplished when other track work is being performed nearby, such as turnout repair, cross tie replacement, etc.
4. Hand tightening to be used as a filler work for a track gang to fill out its work day, await the arrival of track material or the passing of trains, etc.

3. Frozen ,joints

Previous modules have shown the importance of having joints where longitudinal movement can take place between the rails and joint bars along the fishing surfaces.

- This is necessary to permit expansion and contraction of the rails as the temperature changes.

It can be seen that it is possible for frictional forces to be built up along the fishing surfaces which, with the aid of the high bolt tension frequently used, can prevent expansion and contraction of the rails.

Corrosion, together with bolt tension, can result in so-called **frozen joints.**

The best way to prevent frozen joints is by lubrication of the fishing surface. This is most effectively done at the time the joint bars are applied. Oil or graphite is also applied to the fishing surfaces as a part of a bolt tightening operation.

This application will usually be more effective on the lower fishing surface than the upper surface. The oil will trickle down the web of the rail and work into the lower fishing space as the joint flexes under traffic.

Even though it may only be partially effective, this procedure can contribute substantially to avoiding frozen joints.

- Some machines have a feature that lubricates the joints automatically as the bolts are tightened.

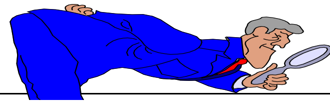
4. Broken Track Bolts

The contraction of rail in cold weather can place high stresses on track bolts, particularly if there is excessive rail end gap in moderate weather due to rail creep.

The rail tends to pull the bolt in one direction from its midpoint.

- At the same time, the joint bars tend to pull the bolt in the other direction near its ends.

If these stresses become too great for the bolts to resist, the bolts will either bend or break. Usually. when a joint pulls apart under such conditions all of the bolts in one end of the joint fail.



After the joint is brought together again, new bolts are installed.

- Some action should be taken to prevent a reoccurrence such as application of rail clips, rail anchors or installation of a longer rail.

These are not the only conditions under which track bolts fail. Sometimes one or more broken track bolts are found at random.

- Frequently, these are replaced with new bolts and no more thought is given to the incident.

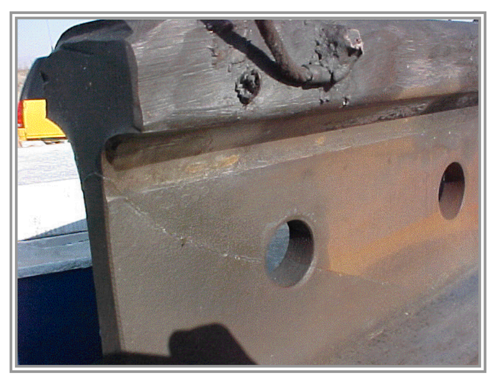
However, these occurrences may provide valuable clues to other conditions that may cause future problems.

Possibly, the stresses that caused the one bolt to break have been weakening the remaining bolts.

- If these bolts were to be removed, you might find surface depressions have weakened these bolts.
- One or more of these bolts may have been bent, but not yet broken.

It may be that the single bolt broke because of an improperly located bolt hole in the rail.

- This condition can result in one bolt having to resist the entire force created by tension in the rail.



At the same time these forces are placing stresses on the bolts the bolt creates stresses in the rail. It is from such stresses that bolt hole cracks in the rail develop.

If it is difficult to install a new bolt because the bolt hole in the rail is not aligned with the bolt holes in the joint bars, the bolt that broke may have been carrying the load for the other bolt or bolts.

- Look closely for signs of a crack in the rail. Improperly aligned bolt holes within the rail can readily be seen without removing the joint bars.

E. Joint Ties

Throughout this module various ways have been shown in which the moving wheels of train equipment can pass higher stresses to the track structure in the vicinity of a joint than at other points.

- One part of the track structure that is subjected to these stresses is the joint ties.
- As a general rule, joint ties have a shorter life than ties which are located away from a joint.

In addition MARTA has recognized that the strength of the track structure at a joint is frequently less than it is in an area away from joints.

For this reason the MARTA standards for joint ties are more stringent than for ties not at a joint.

Sound practice in joint maintenance frequently requires more than minimal compliance with MARTA tie Standards.

- Even in those cases where these standards permit a defective joint tie, it may be poor practice to let the condition continue to exist.

These standards deal with minimum requirements for safety. It is possible to conform to this requirement and have an uneconomical situation. In defective joint ties are permitted by this standard to allow rapid deterioration of the joint, it is usually poor economy.

The deterioration could consist of:

- Rail end or secondary batter
- Wear on fishing surfaces of the rails and joint bars
- Broken joint bars or bolts
- Rapid deterioration of adjacent ties or track surface
- Loose bolts or gauge widening.

These conditions could be much more costly than the savings from the avoidance of renewing the defective ties

For this reason, the maintenance of good joint tie conditions is an essential part of good rail joint maintenance practices.

F. Gauge at Rail Joints

Rail joints will also be a source of problems from the standpoint of maintaining track gauge on curves.

To illustrate this, it is suggested that you make a detailed gauge check on a curve that is showing some tendency toward gauge widening. To make this check, use a track gauge from which actual measurements can be read. If this is not available, use a tape measure.

Be prepared to write each reading on a note pad. In order to prove this point, read the gauge about four times in each rail length. Take a reading at each joint, on both the high and low rails. Take a reading about midway between each of these joints. Indicate which are the joint readings with an **"H"** for the high outside rail joint and an **"L"** for the low inside joint.

When you have completed your readings for the curve, take a good look at your notes. Chances are good that the general trend will be for the gauge to be widest at the high rail joints.

- There may be exceptions to this. In fact, the extreme widest gauge may occur at some other point.

If this happens, it may be due to several poor ties or a sharper spot in the curve alignment where the rail is wearing faster.

The important point to recognize is that, other conditions being equal, there is more likelihood of having critically wide gauge at a high rail joint than at other points.

- This is one more reason why preference should be given to the maintenance of joint ties especially in curves.

G. Track Surface

Rail joints cause more irregular track surface than any other condition.

- These irregularities, together with the cost of maintaining rail joints, are the principal reasons for installing CWR.

The impact stresses, which occur as wheels move over rail joints, tend to break down the ballast support under the joint ties.

- The resulting low spots in the track surface increase the possibility of rapid deterioration of the joint.

The correction of low joint conditions is the principal reason for spot surfacing operations. Sometimes, the presence of rail joints requires the use of special tamping techniques.

This can apply to general raises as well as spot surfacing. Some railroads prefer that joint ties be tamped with an additional insertion of the tamping tool.

- This is done only under the rail on which the joint is located.

Some railroads advocate raising the track so that the joints are slightly higher than the rest of the rail.

- This technique is known as **peaking** and is done in the expectation that the joint will soon settle to a practically level condition.

Some railroads do not recommend this practice. You should determine your company's policy before using this procedure.

H. Joints in CWR

When transits and railroads first began installing **CWR**, it was generally the practice to connect the strings of rail with conventional rail joints.

The patterns of anchoring that are used with CWR are intended to restrain tension in the rail by transferring the loads through the ties to the ballast.

As a practical matter, it is not unusual for a small amount of movement to take place in the rail:

- in the Pandrol clip or rail anchor
- in the tie
- before the ballast system takes full effect.

When this happens, a great deal of stress can be put on the rail joint.

- Sometimes, bending of the track bolts takes place.

This can result in an excessively wide rail end gap that will produce high impact stresses under a train. It is not unusual under these conditions to experience a pull-a-part in cold weather due to broken bolts or broken joint bar.

These joints are also subject to the same conditions that cause other conventional joints to deteriorate.

This includes:

1. Chipped rail ends
2. Battered rail ends
3. Worn fishing surfaces
4. Loose bolts
5. Rail surface irregularities.

Because of the minimal chance of failure in CWR, these conventional joints should receive preferred attention in the correction of defects.

Checking of bolts before the onset of cold weather can reduce the likelihood of pull-a-parts.

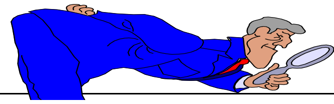
A wider than normal rail end gap may be an indication of bent bolts.

Removal and replacement of bolts one at a time will enable you to see if they are deformed or are excessively worn.

One of the procedures that was adopted in an effort to improve on the restraint that could be provided by a rail joint in CWR was to introduce the use of adhesives between the contact surfaces of the rail ends and joint bars.

- This was done both with conventional joint bars and special joint bars, that provided greatly increased contact area with the rail ends.
- This concept has not gained widespread use, except in the case of the adhesive-type insulated joint.

The procedure that has been most widely adopted for joining strings of CWR is the field weld, which eliminates the need for rail joints.



I. Compromise Joints

Compromise joints are used to connect adjacent rails of different sections. These joints are usually stamped to indicate the rail sections, to which each end of the joint is designed to fill.

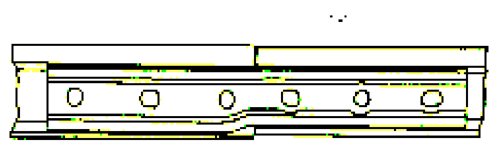
As in conventional joints, two bars are considered as a pair.

Unlike conventional joints, the two bars which form a pair, are not identical in a compromise joint.

Each bar will be marked as **gauge** or **field** only if the width of the rail can be added in the two rail sections for which the compromise joint is intended is different.

It is in these cases that is necessary to laterally onset the rail ends so the gauge side of the rail will be in alignment.

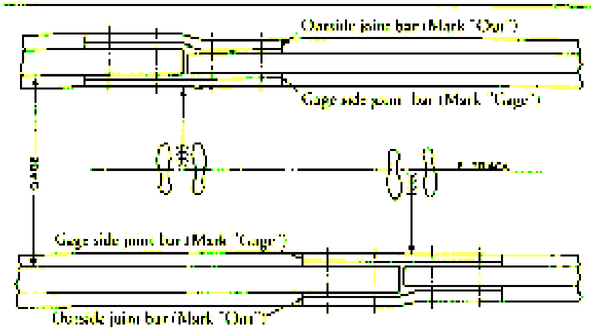
- When the two rail sections have base of the same width, this lateral offset is not necessary.



Compromise joint

Then, the bar that fits on the gauge side of one side of the track will be on the field side on the opposite side.

See the Appendix for a Complete Drawing of a Compromise joint



Compromise Joint

The irregular shape of a compromise joint can cause some unusual stresses to develop in the vicinity of the transitional area.

This transition, to accommodate different rail sections, takes place at the center of the bars, which is the point where joint bars usually receive the greatest stresses.

- Because of this, there is a somewhat greater tendency for compromise bars to break than for conventional joint bars.

Accordingly. compromise joints should receive close inspection at frequent intervals and preferred maintenance.

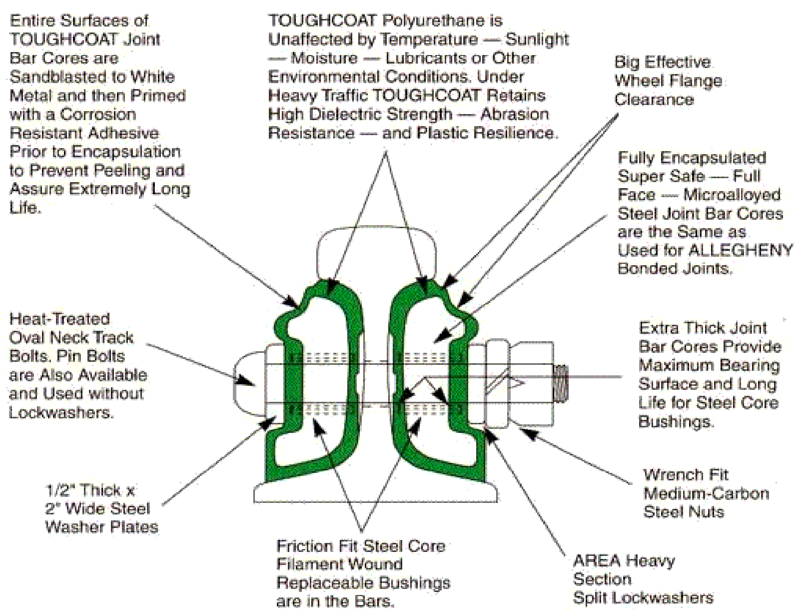
J. Insulated Joints

Insulated joints, which are used to form breaks in electrical circuits within strings of rails, present special maintenance problems.

Additional insulating material not shown in these diagrams includes an end post which Is inserted between the rail ends, and bushings that form sleeves on the bolts so they do not make contact with the rail.

The insulation consists of fibrous or synthetic materials with good electrical insulating qualities.

- Unfortunately, materials that have such qualities invariably have considerably less strength than steel.
- The insertion of insulation between steel components reduce the strength of the joint as compared to a conventional joint.



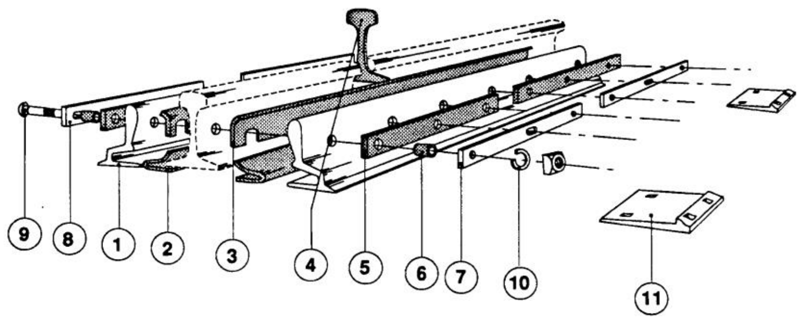
Wear on the insulating material can progress until contact is made between steel parts, that being insulated, is intended to separate.

- This will allow electrical current to flow between these steel parts. This can cause a signal failure.

There are two broad categories of insulated joints: Bolted and Epoxy bonded joints.

The type of rail and service characteristics determines the type of insulated joint used in welded rail territory use epoxy bonded type (MARTA mainline tracks). In jointed rail territory use bolted or hucked insulated type (MARTA yard tracks).

Parts Description for armored joint



1. **Continuous Joint Bar**

   Metal joint bar replaces the normal splice bar on a conventional rail joint. It serves to connect the rail ends together as well as contain the insulation.

2. **Fiber Base and, 3. Head Piece**

   These pieces are used to insulate the metal joint bar from the rails, and therefore, are installed between the rails and the joint bar.

4. **End Post - Fiber**

   End post is a piece of fiber cut out to form an exact cross-section of rail. It provides insulation between the rail ends.

5. **Washer plates - Fiber, 7. and 8. Washer Plates - Steel**

   The washer plates are installed on the outside of the joint bar with the fiber plate in contact with the joint bar. The fiber plates serve to insulate the head and nut of connecting bolts from the joint bar.

6. **Bushing - Fiber, 9. and 10. Bolt, Nut and Spring Washer**

   Each connecting bolt is installed with two fiber bushings that are placed inside the joint bar before the bolts are inserted. They serve to insulate the connecting bolts from the joint bars.

7. **Abrasion Plates**

   Normally the rails are laid on "canted" or sloped tie plates. When an insulated joint is installed, these tie plates are replaced by "Abrasion Plates". The abrasion plates have the same slope as ordinary tie plates. One abrasion plate is used on each tie under an insulated joint. Otherwise the twist given to rails under wheel loads causes the insulation to wear out quickly and the base of the joint will cut into the ties. The abrasion plates protect the rail ends, ties and insulting material from rail twist.

K. Standard Bolted Insulated Joints

Coated Steel Bar Type - Three of the approved manufacturers of these insulated joints:

Allegheny (Toughcoat), Portec (poly-joints) and Seneca. Each of these joints has three major components.

Fiber End Post (one per joint)

The end post is a piece of insulating material cut to approximate the rail cross section. It provides insulation between the rail ends.

Coated Steel Bar (two per joint)

A steel joint bar coated with an insulating material replaces the normal joint bar. It serves as a structural connection as well as insulating the joint.

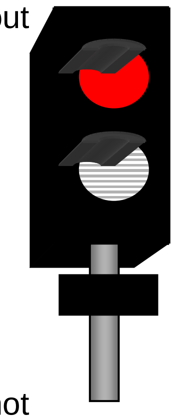
Washer Plate (four per joint)

A steel plate with 3 bolt holes used to reinforce the connection on the outside of the joint.

When spiking this type of joint, ensure that the bill of the spike is turned away from the rail and joint bars. This will prevent the tearing of the insulating coating.

L. Epoxy Joints

1. Adhesive-type Insulated Joints



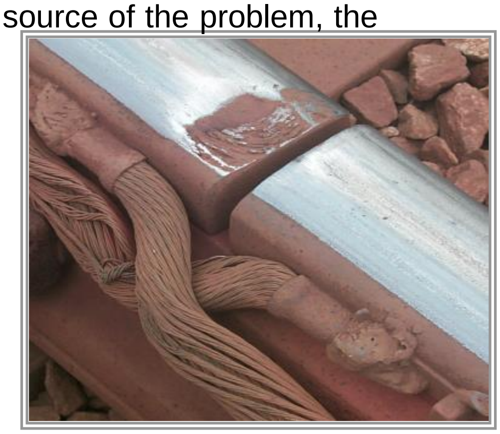
There are many cases in which repairs to an insulated joint are carried out because of failure of insulation.

A signal may have failed or electrical failure of the joint may appear to be intermittent.

Perhaps ATC personnel called your attention to the condition.

Sometimes with this emphasis on replacement of defective insulation, not enough attention is given to the cause of its failure.

- If the insulation is replaced without getting to the source of the problem, the new insulation will wear out in a relatively short time.



Perhaps the joint is surfaced at the time that the insulation is renewed.

- If the ties under the joint are not sound the surface will probably break down again and the insulation will fail prematurely.
- If the ballast is pumping mud, and no effort is made to correct the source of the problem, the surface will probably deteriorate quickly.

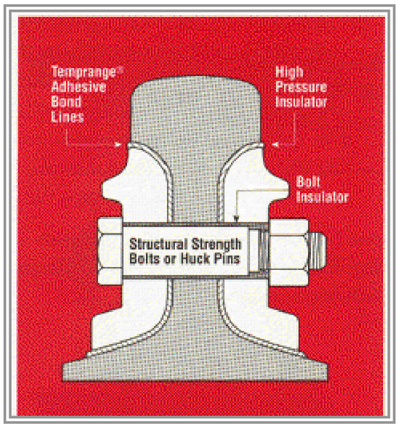
If the rail ends are battered, and they are not built up by welding prior to renewing the insulation. you can anticipate having to do the job again. In some cases, the rail ends may have deteriorated to the point that replacement of the rails is necessary to provide a sound joint.

This type of joint is used in welded rail track. The joint parts are bonded to the rail with an epoxy glue. The parts consist of two special bars, an end post and huck bolts with thimbles.

- Once assembled and cured, the joint is as strong as the rail and usually requires little or no maintenance.

2. Glued joints

Conversely, many times the insulation and basic soundness of the joint can be preserved by the timely performance of such basic maintenance as surfacing of the joint, tightening of bolts or cross grinding of a rail and lip.



Insulated joints that are designed to be installed with glue applied during the course of assembly have great advantages over conventional insulated joints.

1. First, there is much greater resistance to pulling apart of the joint. Additional benefits of this improved strength in tension are fewer shearing stresses on the bolts. and less bearing stress on the bolt hole-surfaces of the rail which reduces the chance of bolt hole cracks.
2. Secondly, as wheel loads pass over the joint, the flexural bending in the joint and rail ends is more uniform. This results in a stronger, stiffer system. It also reduces deterioration of the insulation substantially.

Some transits and railroads prefer to assemble adhesive joints in-track. Other railroads choose to have these joints assembled either by the manufacturer or at a railroad shop facility.

This second method is done with the use of two short pieces of rail.

The entire assembly is then installed in the track assembly by the use of two field welds.

- Those transits or railroads who elect to use the shop assembly method usually do so because of the amount of equipment required, which may become somewhat cumbersome for field use, and the intricacies of the procedures.

Some of these preparation procedures are the need to clean rail ends (usually sand blasting), the care required in mixing the epoxy, protection from contamination, curing of the adhesive and protection from rail traffic.

Track personnel who become involved in installation of these joints on an in-track basis need to follow the manufacturer's recommended procedures with great care in order to avoid failure of the bond between the joint and the rail ends.

M. Installation and Maintenance Responsibility

The insulated joints are used to establish the boundaries of a track circuit.

- At the same time they are used to hold the rails together.

In other words, an insulated joint involves both the track as well as the signal personnel. It, therefore, becomes very important that various responsibilities be defined as to the installation and the maintenance of insulated joints.

The following are some of the responsibilities of the track maintenance work force.

- Track forces are responsible for the proper installation and maintenance of all insulated joints including the renewal of defective components.
- Defective insulated joints must be repaired promptly.

Signal forces **(ATC)** must advise the track forces the location of insulated joints for proper signal operation. The location must not be changed without the approval of Track or ATC Supervisor.

Although it is the duty of the Track Department to install and maintain the insulated joints, they may not realize the importance of accurately installed insulated joints.

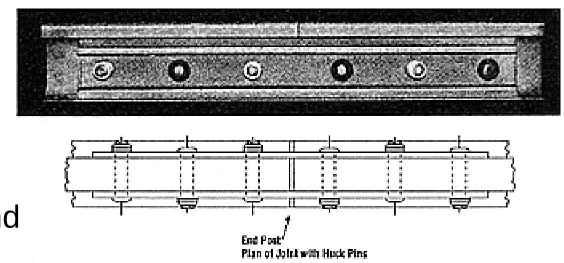
Therefore, all instructions regarding insulated joints should be discussed with, and understood by the track foreman.

- Track Inspectors must make regular inspections of insulated joints.
- ATC Maintainer must inspect insulated joints as instructed and if necessary, arrange for repairs

1. Installation

When installing an insulated joint, it must be realized that it is being installed to:

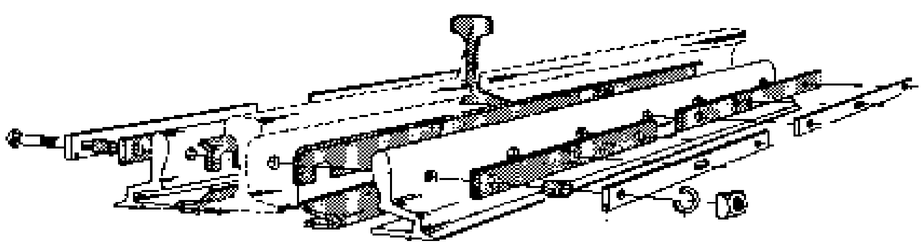
- Provide effective insulating protection.
- Maintain the safety of the track
- Avoid excessive wear and damage to the rail ends
- Provide a reasonable length of service



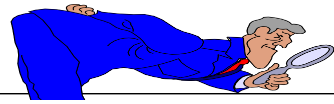
To secure these results, an insulated joint must be:

- Carefully and properly installed, and systematically maintained.

With multiplicity of parts, closely inter-fitting to reduce play and excessive wear, it became very important that an insulated joint be very carefully and accurately installed, according to standard practice rules.



Improperly installed joints cause loss of time and money resulting from frequent renewal of insulation and repair of damage to rails and joints.



2. Preparing the Rail Ends

Remember: It is very important to note that the installation, maintenance or repair of insulated joints must not be started until all train movements, signal operation of automatic crossing protection appliances have been fully protected.

- An insulated joint must not be installed on chisel cut or battered rail ends as the insulating fiber is liable to be damaged. If necessary, turn the rails around or pass them by each other to obtain good rail ends to which the insulated joint may be applied.
- Remove all sharp edges, scale, rust and dirt from rail ends and joint bars before applying the joint.
- Do not attempt to apply the joint when the opening between the rails is too wide or too narrow. The opening can be narrowed or widened by using a rail expander.
- Never use a track chisel to widen the gap between the rail ends.

Before installing an insulated joint, make sure that you have the right kind of joint.

3. Maintenance

The failure of an insulated joint can usually be attributed to improper installation or poor maintenance. When visually inspecting an insulated joint, ask yourself the following questions.

Are the bolts tight

The bolts must he kept tight at all times, and tightened frequently after the joint is first installed, until all parts get firmly set.

Remember: Keep the center bolts slightly tighter than the others and always use a hand wrench.

Do the ties require tamping

The joint must be supported on sound smooth faced ties equipped with plates. The joint ties must be especially well tamped and properly spaced on well drained, clean ballast, otherwise, pumping and churning of the joint will result in excessive wear.

Is the end post too loose or too tight?

The fiber piece cannot withstand the crushing force of creeping track. When this condition is noted, position the rail by using a rail expander and apply sufficient rail anchors on each side of the insulated joint to prevent further movement.

Are the rail ends battered?

After a period of time, the rail ends (especially on new rail) begin to batter down and a lip of steel forms on top of the end-post. This lip must be carefully removed with a hacksaw or file taking care not to damage the end-post. All resulting filing must be cleaned away so not to **short circuit** the insulation. The space between the rail ends must be maintained to the width of the end-post.

Are the fiber base pieces shifting?

Should the base pieces shift, insulation between the metal joint bar and the rail may be broken. The bolts should be loosened and the base piece reset then the bolts re-tightened to prevent movement.

Is either joint bar cracked?

If either joint bar is cracked, it must be changed out immediately.

N. Sliding Rail Joint

The sliding joint is designed to take care of the expansion and contraction problems associated with Continuously Welded Rail.

Expansion and contraction within the unit is permitted by simply allowing the wing rail to move back and forth.

The base (approximately 2400 pounds) provides a solid foundation for the sliding wing rail.

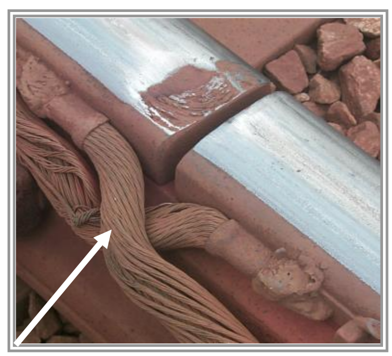
Maintenance Requirements:

- Ensure the wing rail is free to move (remove foreign matter from within the slide area)
- Check and tighten all braces and bolts, especially on open deck bridges
- Ensure the lag bolts have not broken off, if so, replace and tighten
- Check and maintain appropriate expansion gap in accordance with the following expansion gap table.

This type of rail joint can be found on the **YA track.** The YA track is located between the Airport Station and the South Yard. This type of joint relieves the stresses that are placed on the rail and the aerial structure.

Additional information on these expansion joints can be obtained in section 5 of this training manual.

O. BOND WIRES



The A.A.R. defines a Rail Bond (bond wire) as: "A metallic connection attached to adjacent rails to ensure electrical conductivity."

A bond wire must accomplish the following:

- Make and maintain a low resistance electrical connection between rail ends.
- Give a reasonable length of service.
- Give as much broken rail protection as possible and still be economical to install and maintain.

To ensure all these results, bonds must be properly installed and systematically maintained.

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A Standard Of Excellence

Technical Training

Track & Structures

Track Inspection Training

Rail Defects

Section 7

RAIL DEFECTS

MARTA's running rail is standard AREA 115RE section. This rail must be inspected daily in conjunction with the regular walking semi-weekly Track Inspection.

- Any and all rail defects must be noted in the Track Inspection Report.

All visible cracks, which extend beneath the surface of the rail, should be reported immediately to track and Structures Maintenance Supervisory personnel ASAP and the operating speed reduced to 10 M.P.H.

- In addition, the inspector must flag all trains through the defect area.

Upon arrival, supervisory personnel must decide if;

1. The slow order should remain in effect
2. If normal operations should be restored
3. If joint bars should be applied to the defective area
4. If the track should be removed from service until the defective rail can be replaced
5. Any combination of the above.

Supervisory personnel should oversee the conduct of an internal ultrasonic rail defect test if there is any question concerning the rails structural stability.

Listed below are some of the common rail defects, which should be noted in the Track Inspection Report.

Track Safety Standards - Inspection of Rail.

(a) In addition to the track inspections required, a continuous search for internal detects shall be made of all rail in Classes 4 through 5 track, and Class 3 track over which passenger trains operate, at least once every 40 million gross tons (mgt) or once a year; whichever interval is shorter: On Class 3 track over which passenger trains do not operate such a search shall be made at least once every 30 mgt or once a year; whichever interval is longer:

(b) Inspection equipment shall be capable of detecting defects between joint bars, in the area enclosed by joint bars.

(c) Each defective rail shall be marked with a highly visible marking on both sides of the web arid base.

(d) If the person assigned to operate the rail defect detection equipment being used determines that, due to rail surface conditions, a valid search for internal defects could not be made over a particular length of track, the test on that particular length of track cannot be considered as a search for internal detects under paragraph (a) of this section

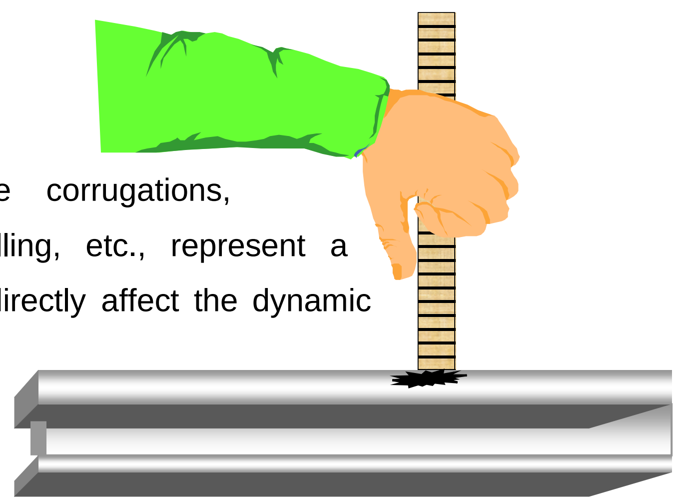
(e) *If a valid search for internal defects cannot be conducted for reasons described in paragraph (d) of this section, the track owner shall, before the expiration of time or tonnage limits -*

(l) Conduct a valid search for internal defects;

(2) Reduce operating speed to a maximum of 25 miles per hour until such time as a valid search for internal defects can be made; or

(3) Remove the rail from service.

A. Running Surface



Rail surface defects, which include corrugations, corrosion, engine burns, surface spalling, etc., represent a significant class of rail anomalies that directly affect the dynamic wheel/rail behavior.

In categorizing and defining rail surface defects, the primary characteristics are:

- Defect depth; usually in 1/1000 of an inch. This is the value between the top of the rail surface and the bottom of the defect.
- Defect wavelength; for periodic defects, such as corrugations. Defined as the distance between adjacent wave peaks (or valleys) and given in inches.

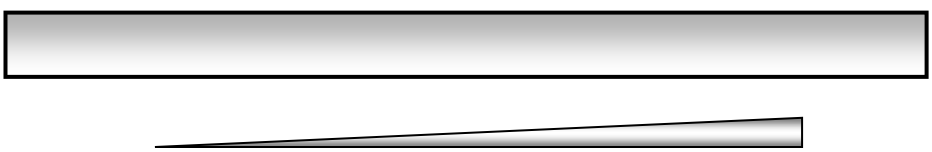
Rail Surface Condition Measurement Tools.

The following tools are recommended for the rail surface condition inspection

All tools must be used with extreme care to avoid bridging insulated joints and contact with energized third rail.

Straight-edge and Taper Gauge

- On conventional joints, one edge of the straight edge is placed at the joint, then using the taper gauge, the batter is determined.
- Rail corrugations can be measured using these tools.



Note: The straight edge and taper gauge is of little or no value in measuring engine burns and other similar flaws in the rail surface.

Dial Indicator and 36 inch Straight-edge

- The 36 inch straight-edge is used as a bridging device. The dial gauges also have an accuracy to +/-0.003 inches.
- Dial Indicator and Parallel 36 inch Straight-edge
- Used for measuring defects that extend over longer distances. The dial indicator can be moved anywhere along the 36 inch length of the straight edges, and can obtain continuous measurements along the length.

Rail Head

Most new rails are installed in main tracks with heavy traffic. Usually, several hundred million tons of traffic will pass over these rails before they are replaced.

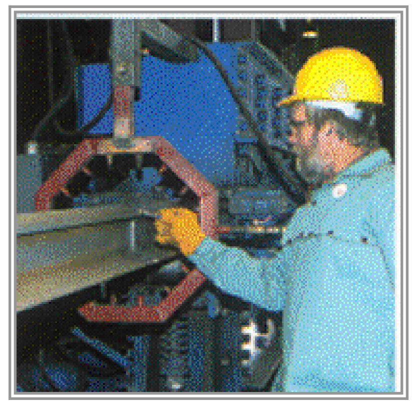
With more Continuous-Welded Rail **(CWR)** being laid each year, defects in both plant and field welds of rails, are becoming more frequent.

- Rail weld defects usually progress from inclusions or slag entrapments at the weld interlace.

- Some longitudinal weld defects in the mid-web area may result from residual stresses in the weld area or stress risers resulting from improper removal of upset metal.

Inspection of standard rail begins on the manufacturing line. This inspection includes a preliminary inspection before straightening, grinding, drilling, etc.

The purpose of the preliminary inspection is to check identification and lengths and to detect harmful surface defects that would eventually cause the rail to be rejected.



After preliminary inspection, the rails are cold straightened in presses or mechanical roller straighteners.

- Residual burrs are removed from the rail ends and the rail ends are chamfered, beveled and drilled if required depending upon the intended eventual use for the rail, i.e., bolted rail or continuous welded-rail.
- All rails are closely inspected for straightness and other physical dimensions.

The **AREMA (American Railway Engineering and Maintenance-of-Way Association)** per the revised specifications effective in August 1988 requires ultrasonic inspection of rails in the manufacturing line.

The inspection of rails must be made for internal imperfections unless it has been agreed between the purchaser and the manufacturer that a manual ultrasonic inspection of the area within 12 inches of the rail end may be used in lieu of the in line inspection.

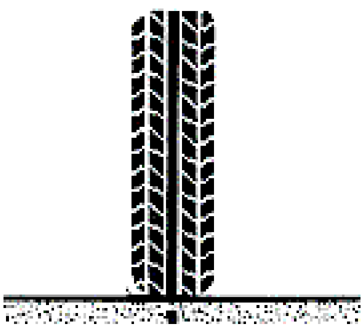
- These test standards are not addressed in this lesson; they are defined in **AREMA's Specification for Steel Rails**.

The relatively small amount of friction developed by the wheel-to-rail combination permits the hauling of large tonnage's with minimal locomotive power.

- This capability has led to substantial increases in the weight placed upon each wheel.
- Some of the larger increases have occurred in recent years with 286,000-pound railcars becoming more common.

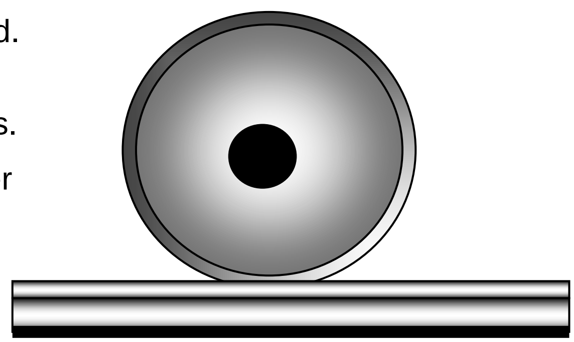
One of the characteristics of the wheel-to-rail combination is the lack of deformation under load, such as happens with the rubber tire upon a road.

- This quality of steel is essential to the small amount of friction developed in the movement of rail equipment.



- It results, however, in very concentrated loads being placed upon both rail and wheel at the point of contact.

In this module, some of the things that happen to rail as a result of these wheel loads will be examined.



Defective rails may be discovered in various ways. At its worst, a rail that fails in service is found after it has caused a derailment.

In other cases, it may be located because it broke through and caused a signal failure.

Train operators who either see a broken rail or hear the wheels of their train pounding on the break find some service failures.

- Others are located by track inspection before interruptions to rail traffic can occur.

Development of Defects

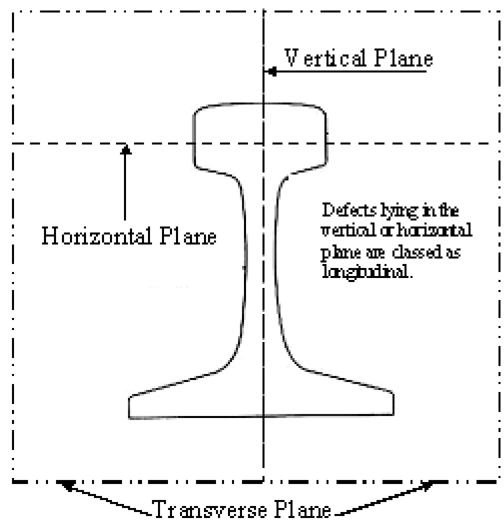
The growth of a rail defect depends on a great many variables.

- The chemical composition of the rail and the amount of rail flexing are factors, which must be considered.

The type of rolling stock (freight, passenger, or motive power), its weight, and its condition of repair are important, as well as the frequency of these loads.

The condition of the roadbed and weather changes which result in track movement also affect growth. With so many variables contributing to development, it is impossible to predict accurately the growth of any defect.

Surface defects may simply enlarge under the batter of passing wheels, or may furnish the focal point for an internal separation.



Internal defects actually experience a growth in size, although the type of growth cannot be classified, nor the defect size measured (except by hand testing) until the rail is broken to show the face of the defect.

B. Visual defects

External defects are not always easily detectable unless they have resulted in an obvious break in the rail or a breakout of a piece of rail from the running surface.

Visual inspection is sometimes aided by a mirror to check under the head of the rail and discover the more obvious defects such as, vertical split heads and half-moon base breaks.

However, this type of inspection cannot detect those internal separations of the steel on the railhead known as a transverse defect, and frequently overlooks horizontal split heads.

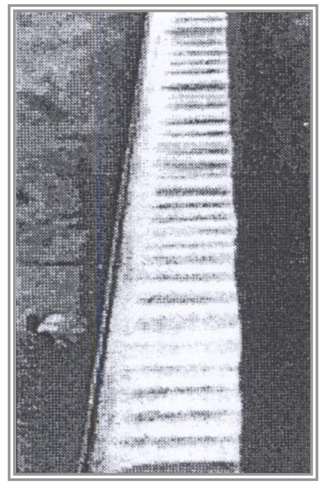
- Some rails contain irregularities that are apparent to a trained inspector, even though the rail has not yet failed.
- Some of the conditions are considered to be defects because under continued service they will lead to failure.

Railhead Surface Defects

Corrugation

Corrugation, sometimes called washboard rail, is a series of waves or variations in top of the railhead which are more or less accentuated and irregular.

- The short wave or rail length of the corruption usually varies from two to three inches.



Intermediate wave corrugation or undulations at times could exceed 10 to 12 inches in length.

- This type of condition is seen on heavy freight operations.

The very long wave corrugations have a wavelength greater than 24 inches and are common on very high-speed operations. Furthermore, this type of corrugation has a very shallow depth between peaks.

Corrugations have the appearance of regular bright and dark streaks across the running surface of the rail.

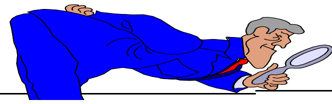
Corrugation is caused by uneven rail wear.

- It is generally attributed to a repetitious wheel sliding action of some nature whether through heavy braking or lateral motion across the rail surface.
- It is not considered to be a serious defect but is usually removed from high-speed track because of the rough ride it causes.

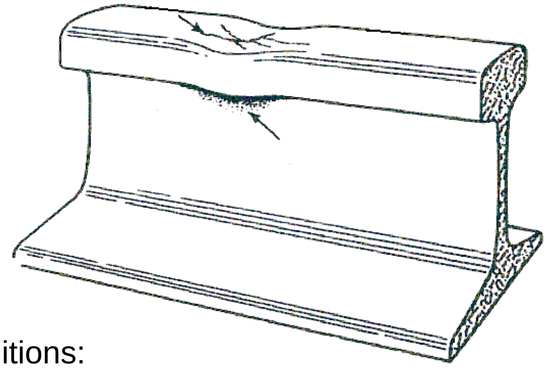
Crushed head

Crushed head is a rail flaw caused by flattening or drooping of several inches of the railhead.

- It is usually accompanied by a crushing down of the metal but with no signs of cracking under the head.



The crushed head usually originates by a soft spot in the steel of the head, which gives way under heavy wheel loads.



- The continual passage of the heavy wheel loads causes it to grow. Also higher train speeds and increasing depth of the flat spot accelerate growth.

Crushed rail can be identified by the following conditions:

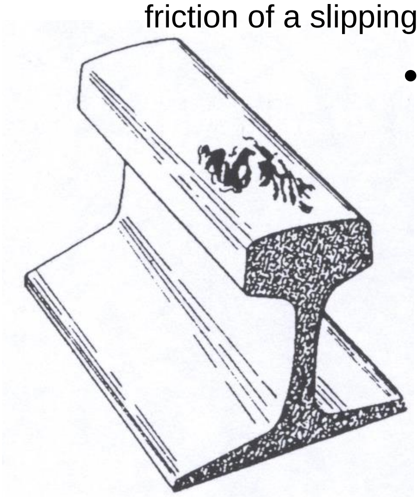
1) A flattening and widening of the head for several inches, with the entire head sagging.
2) Small cracks in the depression on the running service.
3) In advanced stages, crepe (wrinkled) surface or a bleeding crack at the fillet under the head

The crushed head is not a serious defect, but it is generally removed from high speed track because:

It causes rough riding of rolling stock. Points of concentrated loading may develop defects.

Engine burn or burned rail

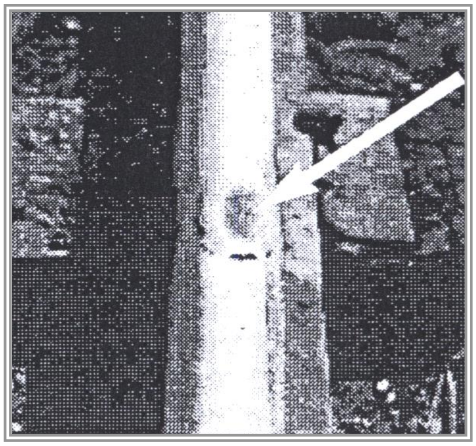
Engine burn is a defect consisting of damage to the rail tread caused by the high friction of a slipping locomotive wheel.



- The locomotive driving wheel overheats and displaces wheel tread metal on the running surface.
- The burn does not actually grow, however, the damaged area may gradually chip out and roughen under repeated traffic.
- The engine burn is also known as wheel burn.

The presence of an engine burn in the track can also present other maintenance problems. The irregularity on the running surface of the rail creates an impact stress each time a wheel passes over it. This can produce increased deterioration of the supporting ties.

Many small engine burns remain in the track for long periods of time because they are not large enough to create pounding of an appreciable amount. Others have the irregularity minimized by grinding off upset metal, which has been displaced or disturbed by some other action.



This can be an effective temporary measure until the burn can be welded or the rail replaced. Depending on the severity of the depression, a slow order may be appropriate to reduce impact stresses until the condition can be corrected.

Flaking

Flaking is a rail defect consisting of the gouging of metal on the railhead; it is indicated by small chipping and cavities.

- It is a progressive horizontal separation on the running surface of the rail near the gauge corner, with scaling or chipping of small slivers.

Flaking should not be confused with shelling, as the flaking takes place only on the running surface near the gauge corner of the rail and is not as deep as shelling.

- It usually occurs on the high rail of curves.

While flaking is not considered to be a serious defect, it sometimes develops into shelling.

Flaking originates at the surface of the rail. It is prevalent on the high side of curves, switch points. and locations where concentrated loading on the tread and gauge corner cold works the steel.

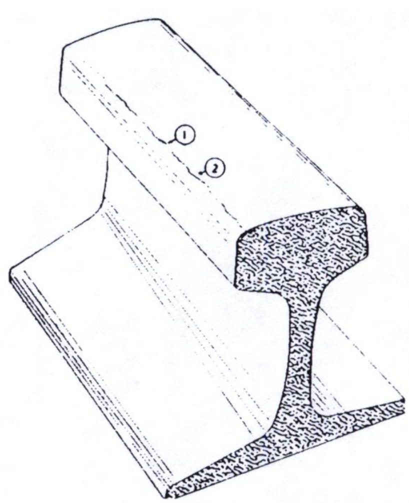
The growth depends on the loading. The separation progresses about 1/32 inch below the running surface toward the gauge side of the head, usually coming to the surface close to that point where the tread contour turns downward at the gauge side.

1) Very shallow depressions with irregular edges occur on the running surface near the upper gauge corner. They generally will not occur more than one fourth inch from the gauge corner of the rail.
2) Horizontal cracks along the running surface near the upper gauge corner of the railhead resemble small slivers.

Head check

A head check is a rail defect consisting of shallow surface or hairline cracks, which appear in the gauge corner of the railhead.

- They appear at any angle with the width of the rail.

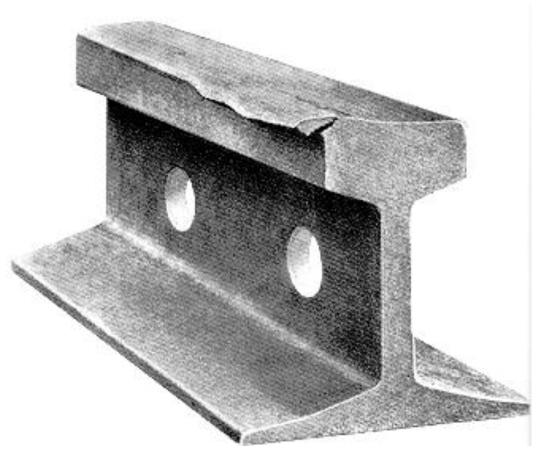


Head checks generally run at a 45-decree angle to the axis of the rail: they usually occur on the high rail of curves. Concentrated wheel loading at the gauge corner of the railhead causes them. Detail fractures can originate from head checks.

Flowed rail

A flowed rail defect consists of the rolling out of the tread metal beyond the field corner, with no breaking down of the underside of the head.

- Flowed rail is not a serious defect.



Flow is due to distortion of the rail metal under repeated loads. This gradual change of the head contour does not damage the metallic structure of the metal.

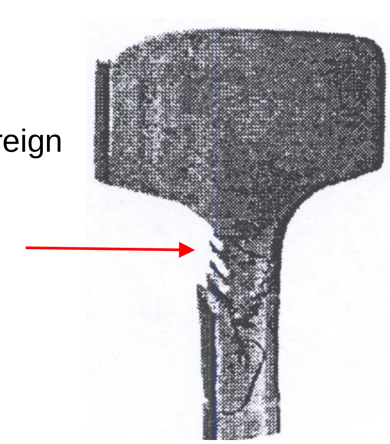
Flowed rail is a change in shape rather than a growth. It occurs, predominately in curved track, under repeated service. The extent of the change is usually proportionate to the length of service of the rail.

- Rail in tangent track may also become flowed, although at a slower rate than in curved track.

Appearance of flow in rail as shown in the photo, shows this section of rail with head flowed to field side, some of lip cracked or broken off.

1) Surface metal on the head flowed on the field side, giving a creased appearance on the running surface near the field.
2) A smooth protruding lip (which may extend the length of the rail)
3) In advanced stage, flow becomes like a blade, jagged, or non-uniform, and may hang down or separate from the railhead.

Mill defects



Mill defects are deformations, cavities, seams. or foreign material found in the head, web or base of a rail.

- They occur when the ingot is poured.
- Slag, gas, or foreign material may be included.

Metal that splashes on the side of an ingot mold may cool and oxidize to some extent before fusing with the liquid metal. Although the defect does not actually grow, it may furnish the point of origin for a transverse or longitudinal separation. Further development depends on the type of mill defect, its location in the rail, and loading of the rail.

Production factors that contribute to the manufacture of inferior rails have been minimized through refinement in rail mill practice, but invisible internal defects still occur in the latest types of rail.

- Currently many rails remain that were rolled prior to the development of the more modern rail production techniques.

Conditions caused by mill defects:

1) A deformation of the railhead which can cause passing car wheels to batter the rail severely
2) Broken out inclusions leaving large or dangerous cavities in the side or running surface of the railhead.

Mill defects are a serious defect if they are deep or large enough to cause the development to increase.

Shelling (shelly spots)

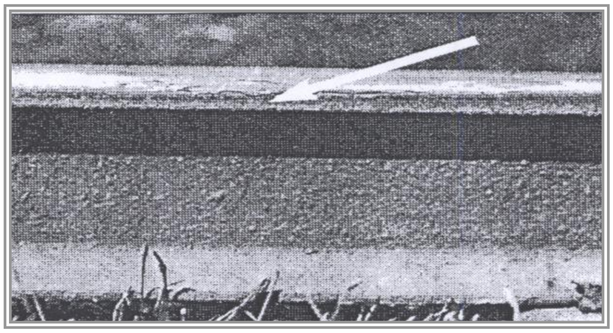
Shelling, sometimes called Shelly spots, is a rail defect consisting of shell-like flakes of steel that have come off the railhead. It is a progressive horizontal separation that may crack out at any level on the gauge side, generally at the upper gauge corner.

It extends longitudinally, not as a true horizontal or vertical crack, but at an angle related to the amount of rail wear. Very shallow shells are called spalls. Also, in the case of a small shell there may be no surface evidence.

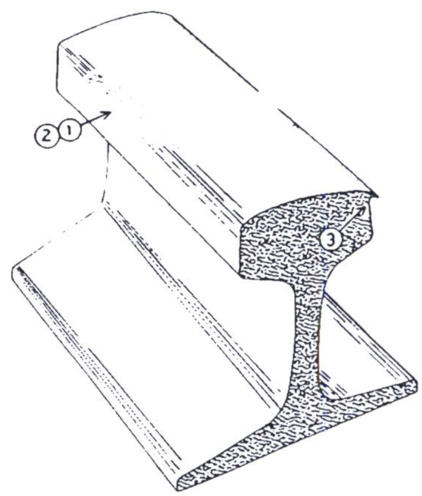
The existence of the shell maybe apparent only after the railhead is broken or sectioned.

The exact origin of shelling has not been definitely determined.

Shelling is prevalent at curves and where excessive pressure is exerted on the railhead. It is accelerated if streaks or small seams are present and provide stress concentration points. Uncapped shell often shows these characteristics of origin. The growth depends on the loading. The separation progresses in the path of least resistance. Shelling may turn down to form a transverse separation, in which case the defect would be classified as a detail fracture from shelling.



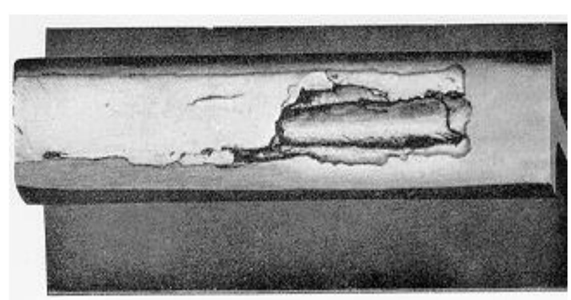
1) Dark spots are irregularly spaced on the gauge side of the running surface.
2) Longitudinal separation occurs at one or several levels in the upper gauge corner, with discoloration from bleeding.
3) If rail is turned, shelling will appear on the field side, with an irregular overhanging lip of metal. Appearance is then similar to flowed metal.



Shelling is potentially dangerous because it occurs most frequently in curve territory and transverse separation may develop at any stage of shelling or at any point along the shell.

Slivers

Slivers, sometimes called rail sliver, is a rail defect consisting of a thin tapered mass of metal that has separated from the surface of the head, web or base of a rail.

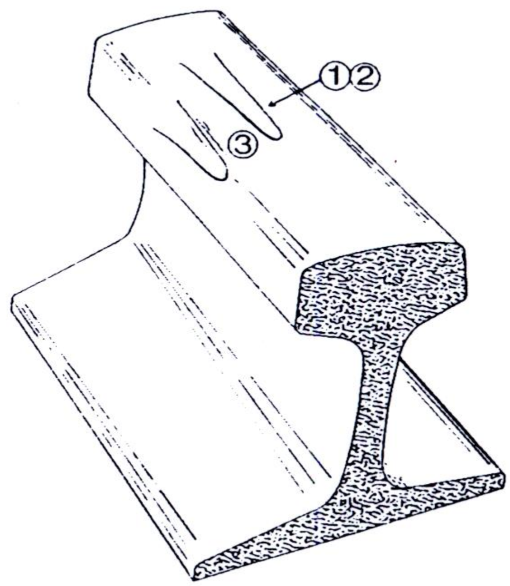


Slivers occur from an imperfection during the rolling process, when a small pre-oxidized section of rail laps over instead of flowing and welding under pressure of' the rollers.

Slivers separate rather than grow, but may chip off, cause batter, or furnish a point of origin for a transverse or longitudinal separation.

- They are not a serious defect.

1) Thin slivers (similar to wood slivers) are on the Surface of the railhead and parallel to the rail length.
2) Darkened slivers are shown (in advanced stage) giving an appearance much like the vertical split head but without any spreading or crushing of the railhead.
3) Slivers on the side of the railhead. Such slivers may be both shorter and thicker than slivers on the running surface. All slivers are generally less than 1/8 inch thick. They form part of the rail contour, lying flat on a surface, but may be cracked loose from rail metal on three sides. If a sliver has been dislodged, only an indentation will remain on the rail surface.



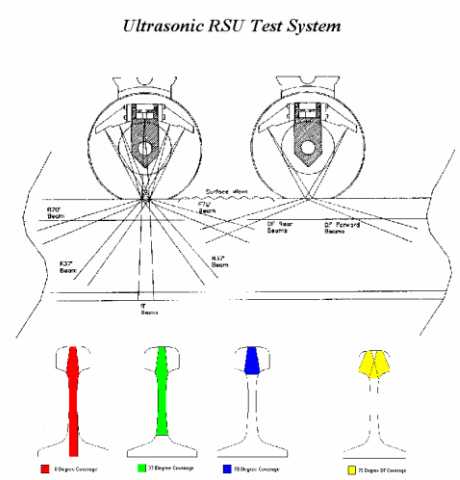
D. Internal Defects

The other general classification is that of internal defects which the use of special inspection equipment.

- It may consist of a small device that is used when inspecting on foot.
- Other types involve on-track or hi-rail equipment.

Internal rail defects are best detected using ultrasonic and induction rail defect equipment.

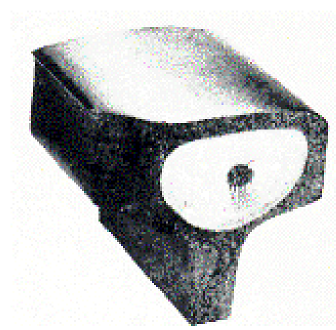
- The most widely used type of equipment is the **Sperry Car** which is operated by Sperry Rail Services to inspect the rail for such things as corrugation, engine burns, high & low welds and other rail defects.



Sperry equipment locates defects that are similar to those that result in many service failures. Frequently, the detection equipment locates defects that are entirely internal. Internal defects can usually be accurately classified without breaking the rail.

Each of the commonly recognized types of rail failures will be described and discussed. The definitions used are those of the **MARTA Track Safety Standards**

Transverse Defects in the Railhead



A transverse defect is any one of a group of defects with progressive fractures that occur in the head of the rail and has a transverse separation, of at least 5% of the cross sectional area.

- This general classification is made when the defect is found in the track.

If the rail is broken for examination, the transverse defect could be accurately identified as one of the following:

Compound fissure
Reverse detail fracture
Detail fracture
Engine burn fracture
Detail fracture from head check

Weld burn fracture

Detail fracture from shelling

Transverse fissure

The transverse defects will generally grow within the railhead until the rail is sufficiently weakened to permit a complete break, under load, across the head, web and base of the rail.

The growth of the defect within the railhead may be very slow when the defect is small or quite rapid when the defect is large.

- Other transverse defects, which are still found in rails in significant numbers, are detail fractures, engine burn fractures, and occasional compound fractures.

Progressive transverse defects will also develop underneath engine burns or rail welds that have been resurfaced by welding when the area being rebuilt is not properly cleaned or cooled during the process.

A crack at right angles to the running surface. This is usually on the field or gauge side of the head, or at the fillet under the head, occasionally on the running surface.

Discoloration (red or purple oxidation) around the crack.

- This is called bleeding and is caused by internal rusting.

A crack at upper gauge corner of the railhead.

- On turned rail, this condition may occur at the field corner.

Numerous gauge cracks are often present, but should not cause suspicion unless a single crack extends much farther down the side and much farther across the running surface than the other cracks.

A horizontal crack in the side of the railhead which turns upward or downward at one or both ends and is usually accompanied by bleeding.

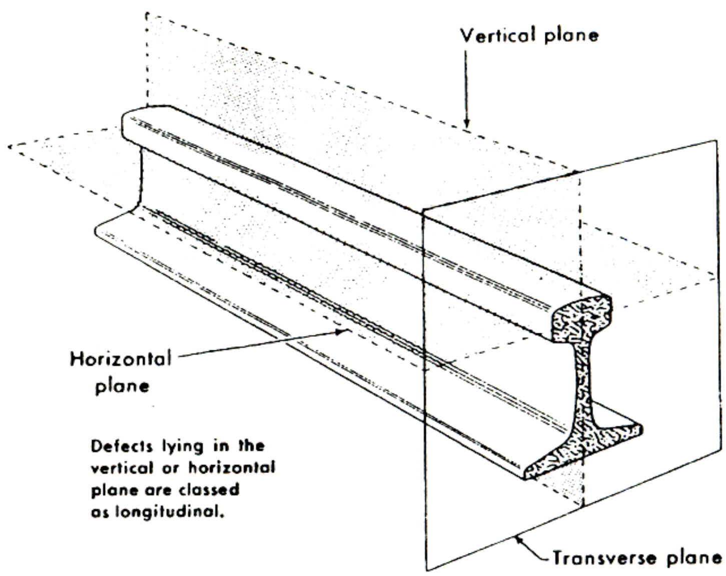
- Under such conditions a flat spot will generally be present on the running surface.

A crack extending downward at tight angles from a horizontal crack caused by shelling of the upper gauge corner of the railhead.

- Shelling can be identified by the presence of a slight discoloration on the gauge side of the running surface. On turned rail, the shelling area may be found at the field side.

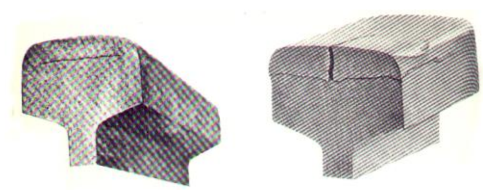
Compound fissure

Is a progressive fracture originating in a *horizontal split head which turns up or down) in the head of the rail as a smooth, bright, or dark surface progressing until substantially at a right angle to the length of the rail.*



Compound fissures require examination of both faces of the fracture to locate the horizontal split head, from which they originate.

Development of compound fissures



An internal longitudinal seam, segregation, or inclusion with the railhead starts the development of a horizontal split head.

- This horizontal separation, at times, may be very short, as little as 1/8 inch in length.
  The essential condition for a defect to be classified as a compound fissure is that there is both horizontal and vertical separation.
- Also, unlike the transverse fissure, there is no nucleus within the defect.

Compound fissures are dangerous for reasons similar to those that apply to the transverse fissure.

(a) They can occur at several locations in the same rail.

(b) In some cases, there is no visible defect until the rail actually breaks.

(c) When the rail breaks, it is usually a complete transverse break across the entire rail.

Detail fracture

Is a progressive fracture originating at or near the surface of the railhead. These fractures should not be confused with transverse fissures, or other defects, which have internal origins. Detail fractures may arise from Shelly Spots head checks, or flaking.

Development of detail fracture

Detail fractures have a transverse growth that may appear to resemble that of the transverse fissure. There are two differences.

1) The defect does not contain a nucleus in the case of the transverse fissure. The detail fracture originates at or near the surface.
2) The transverse fissure originates at an internal nucleus. Shelly spots. Head checks and flaking will be discussed later in this module in the section on surface defects.

It is possible for a detail fracture to grow quite quickly. Failure often takes place before there is any visual evidence of the defect. Like the fissures, detail fractures lead to a complete transverse break across the entire rail.

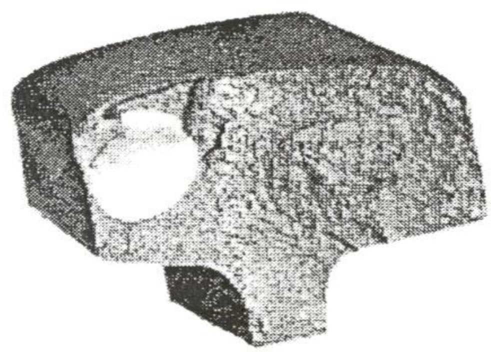
Detail fracture from head check

The detail fracture from head check is a progressive fracture starting at the gauge corner of the railhead and spreading transversely through the head. It originates in the upper gauge corner of the rail, usually caused by the weight of concentrated loading which deforms the railhead. The detail fracture from head check is a dangerous defect because:

- Tendency to occur several places in the same rail
- Service failure is the result of a complete break of' the rail across the head, web and base.

Detail fracture from shelling

The detail fracture from shelling, whether visible or internal, is a progressive fracture starting from a longitudinal separation close to the running surface of the railhead, then turning downward to form a transverse separation substantially at right angles to the running surface.



It usually originates from a longitudinal seam or streak near the running surface on the gauge side (field side if the rail has been turned or transposed).
The separation progresses longitudinally, not as a true horizontal or vertical crack, but at an angle related to the amount of rail wear on the gauge corner.

After some distance, the crack turns downward and inward to form a transverse separation.

- Positive identification cannot be made until the rail is broken

Identification after the rail is broken

The longitudinal separation and the streak or seam in which it originated is not always exposed. The transverse component resembles that found in a transverse fissure except that:

- No nucleus is present in the transverse separation.
- The transverse separation always spreads from a longitudinal separation in the upper gauge corner.

The detail fracture from shelling is a dangerous defect because:

- Growth may be rapid or sudden.
- Failure frequently occurs before the defect becomes visible.
- Service failure is a complete break of the rail across head, web and base.

Reverse detail fracture

The reverse detail fracture is a progressive fracture starting at either bottom corner of the railhead, spreading transversely through the head.

- The origin is a stress riser on the cold rolled lip on the bottom corner (gauge side or field side of transposed or turned rail) of the railhead and typically associated with severely worn rail and high axle loading.

The growth is normal to a size of ten percent and is often rapid or sudden prior to complete failure of the rail section.

- A positive identification cannot be made until the rail is broken.

The specimen exposes a transverse separation, which starts at the lower gauge corner and spreads in crescent-shaped rings radiating from the point of origin.

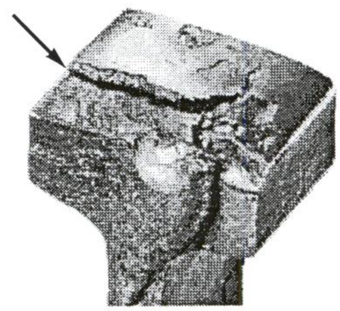
Reverse detail fracture the reverse detail fracture is a dangerous defect because:

- It can occur in several places in the same rail.
- It can fail completely below a 15 percent size.
- Failure typically occurs at 80 percent of the speed at the time of a typical detail fracture.
- Service failure is a complete break of the rail across head, web and base.

Engine Burn Fracture

Is a progressive fracture originating in spots where driving wheels have slipped on top of the railhead. In developing downward, they frequently resemble the compound or even transverse fissure with which they should not be confused or classified.

Development of Engine Burn Fracture



Many surface defects on the railhead similar in appearance to the rail surface remain in track for long periods of time without developing internal defects.

- The existence of such a surface defect does not necessarily mean that the affected rail should be replaced.
- The proper treatment of rails with engine burns caused by slipping driving wheels will be discussed in succeeding modules.

If severe slippage of train or locomotive wheels occurs, each driving wheel will create a surface defect on the head of the rail on which it is supported.

These defects may be minor, or severe enough to require verse separation immediate replacement of the affected rails.

The slippage causes rapid heating of the rail close to the surface of the railhead.

- Cooling may also be quite rapid.

This rapid heating and cooling of the surface metal can cause a horizontal separation to occur just under the surface of the railhead. In addition, an irregularity is left in the surface of the railhead.

- This causes pounding as each wheel moves over the burn.

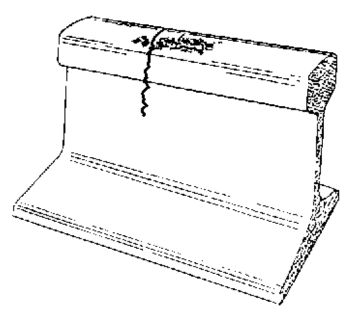
This combination of circumstances can cause growth of the horizontal separation, which can turn downward and form a transverse separation.

Although failure sometimes takes place before the defect becomes visible, one or more cracks may be visible on the rail surface in the vicinity of an engine burn, prior to failure. The picture on the previous page illustrates the appearance of typical cracks that develop on the surface as an engine burn fracture grows.

Appearance in Track - No sign of a transverse separation is visible until the defect reaches the rail surface (cracks out). An engine burn fracture may then be recognized by one or more of the following characteristics identified in the reference material listed below.

Gauge Side

1) A hairline crack on the side of the head, in the immediate vicinity of an engine burn on the surface, and at right angles to the running surface. The crack may be visible on either the field or gauge side of the head.



2) Transverse thermal cracks extending from the burn to the gauge corner and down the gauge side of the head as transverse components for at least 1/8 inch.

Field Side

3) A cracked out horizontal separation visible on the field side of the railhead under the burned area, accompanied by one or more thermal cracks which extend transversely to the gauge corner.

Welded Burn Fracture

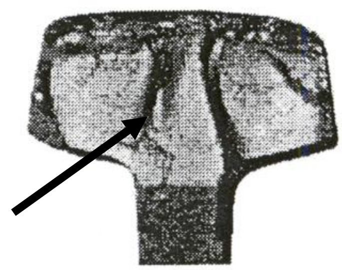
The welded burn fracture is a progressive transverse separation in the head of the rail, which develops substantially at right angles to the running surface at an engine burn, which has been resurfaced by welding.

A welded burn fracture is sometimes the result of insufficient **wash out** or cleaning of an old engine burn prior to resurfacing by welding and this essentially fails to eliminate thermal cracks created by the original driver burn.

Improper cooling of a resurfaced burn can also create new thermal cracks.

- No sign of a transverse separation is visible until the defect reaches the rail surface (cracks out).

A welded burn fracture can then be recognized by a crack at right angles to the running surface. The crack may be visible on the field or gauge side of the railhead or underneath the head in the head fillet area.



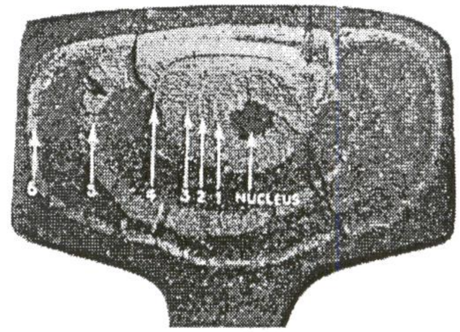
Welded burn fracture with transverse separation found beneath a resurfaced engine burn

Transverse Fissure

Is a progressive crosswise fracture starting from a crystalline center or nucleus inside the head from which it spreads outward as a smooth, bright, or dark, round or oval surface substantially at a right angle to the length of the rail. The distinguishing features of a transverse fissure from other types of fractures verse fissure or defects are the crystalline center or nucleus and the nearly smooth surface of the development which surrounds it.

Development of Transverse Fissures

The transverse fissure can be readily identified after a complete break occurs, by the presence of a nucleus within the defect.

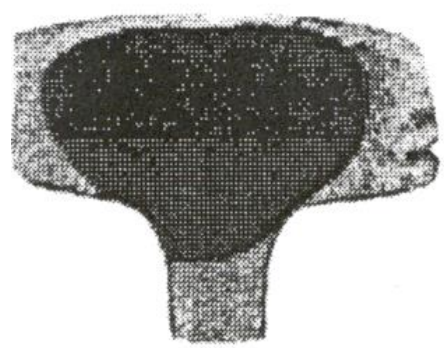


- This nucleus may have been caused by a shatter crack, a small inclusion of an impurity with the steel or a blowhole.

At first, the outward growth from such a defect is usually very slow. See the **MARTA Track Safety Standards** for required remedial action.

Face of transverse fissure was blackened or oxidized by air when separation reached surface at fillet

Since transverse fissures are caused by defects in the rail at the time of manufacture, the answer to the problem was sought in the rail manufacturing process.



- The solution was to be the adoption of the control cooling process.

The rate of cooling, after the rail is rolled, is controlled within specified limits by this procedure.

- Control cooling of rail was adopted by the steel mills in 1937 and has been highly successful in the prevention of' transverse fissures in rail manufactures since that time.

Where a transverse defect is located and positive identification cannot be made as to the type, the possibility that the defect is a transverse fissure must be considered, if the rail is not control cooled.

Rails, which are known or suspected to contain a transverse fissure, are dangerous for three reasons:

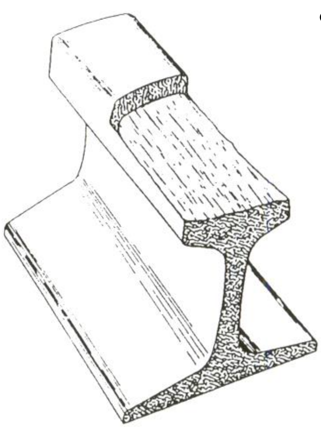
- The defects in the steel that cause transverse fissures are likely to he found at other locations within the same rail. Application of joint bars to a known transverse fissure offers no protection against failure elsewhere in the rail.

In most cases, there is not visual defect until the rail actually breaks.

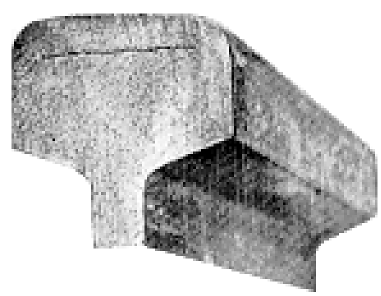
- When the rail does break, which is a complete transverse break across the entire rail, it is highly dangerous.

Longitudinal Defects in the Railhead

Longitudinal defects, such as vertical split heads and horizontal split heads are discovered in considerable numbers.



- Rail that has been relayed or otherwise disturbed after years of service in one position is particularly susceptible to the development of longitudinal defects due to altered stresses and changed loading patterns.
- It has been noted that wheel-to-rail loading changes, which result from contour grinding, have aggravated certain dormant rail conditions.



Horizontal Split Head

Is a horizontal progressive defect originating inside of the railhead, usually one-quarter inch or more below the running surface and progressing horizontally in all directions, and generally accompanied by a flat spot on the running surface. The defect appears as a crack lengthwise of the rail when it reaches the side of the railhead.

Development of Horizontal Split Head

Internal seams, segregation or inclusions within the railhead cause horizontal split heads.

- The splits develop longitudinally (lengthwise in the rail) in a horizontal plane.
- They can be short or quite long before the head of the rail breaks out.
- If the split becomes transverse, the defect is classified as a compound fissure.

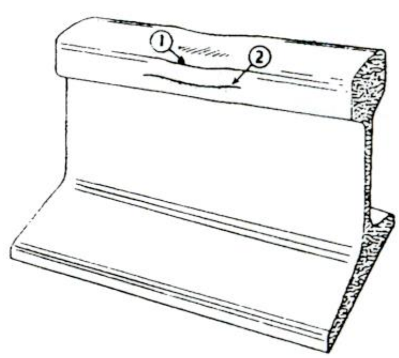
Evidence of horizontal split heads is usually visible before failure occurs. In the first stages, a flat spot or dip usually develops on the top of the railhead. There may be a slight widening of the head.

General appearance of a Horizontal Split Head

In the second stage, a horizontal crack appears on either the gauge or field side of the railhead. These conditions are illustrated in the figure below.

1) Before cracking out, a horizontal split head of
   moderate size will cause the appearance of a flat spot on the running surface, accompanied by a slight widening or dropping of the railhead. The flat spot will be visible as a dark spot on the bright running surface.

2) After cracking out, the horizontal split head will appear as a crack in either the field or gauge of head, or both, and at least 1/3, of the way below the top of the railhead. In rail laid without cant, the split will usually crack out first on the field side.



The horizontal split head is a serious defect because:

1) It tends to occur several places in the same rail, since the seam or segregation may exist throughout the rail length.
2) It may develop into a compound fissure, in which case service failure is a complete transverse break.

Vertical Split Head

is a vertical split through or near the middle of the head and extending into or through it. A crack or rust streak may show under the head close to the web or pieces may be split off the side of the head.

Development of Vertical Split Head

Internal segregation, seams or inclusions within the railhead also cause vertical split heads. They usually develop rapidly and lengths up to 10 feet are not unusual.

An experienced inspector can frequently detect a vertical split head in the rail.

At times, widening of the railhead or sagging of one side of the railhead may be noted.

- When these signs appear, the existence of a vertical split may be further verified by looking under the railhead at the fillets between the head and web.
- A rust or dark streak or a bleeding crack is further evidence of the presence of such a defect.

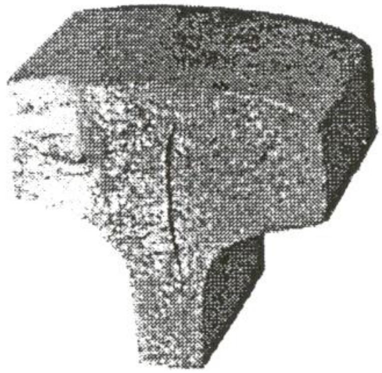
Visual Signs of Vertical Split Head

(1) A dark streak on the running surface.

(2) Widening of the head for the length of the split. The side of the head to which the split is offset may show signs of sagging or dropping.

(3) The dropping of the head causes a rust streak to appear on the fillet under the head.

(4) In advanced stages, a bleeding crack will be apparent at the fillet.



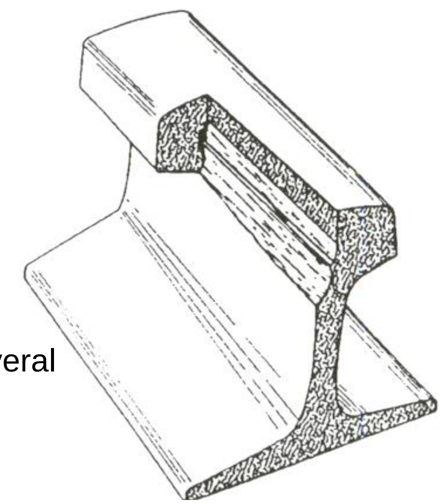
Vertical split heads usually grow to considerable size before such signs are visible.

The length of these defects increases the likelihood of severe disintegration of the rail when a piece breaks out of the railhead.

A vertical split head is a dangerous defect because:

- It is usually not visible on the surface until it has grown to a length of several feet.

Since a vertical split head usually extends longitudinally for some distance a considerable portion of the railhead is weakened.



If the split is on the gauge side of the rail and breaks off in service, car wheels will tend to climb to the top of the rail or drop between the rails causing a derailment.

- Upon service failure the rail may break into several pieces.

E. Web Defects

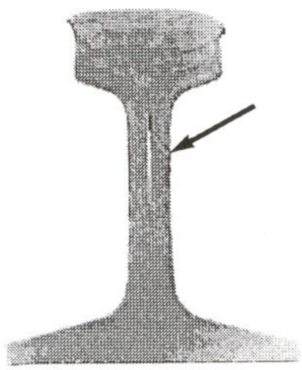
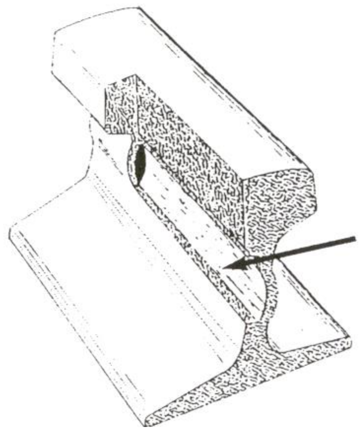
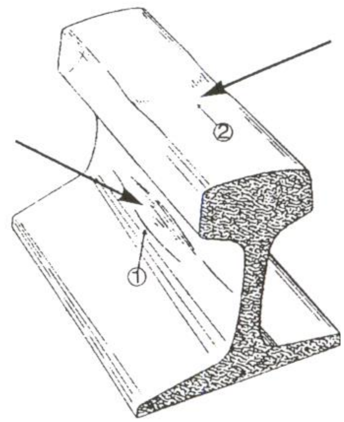
A web defect is any progressive fracture occurring in the web of the rail having, primarily, a longitudinal separation. These general classifications of defects can be identified on the rail as follows:

Piped Rail

is a vertical split in a rail, usually in the web, due to failure of the shrinkage cavity in the ingot to unite in rolling.

Bulging of the web on either or both sides. Shallow cracks due to distortion may be found in the bulging surface.

- A slight sinking of the railhead is shown in the area above the pipe.

Development of Piped Rail

Piped rail is not a commonly found defect. The origin is a wide longitudinal seam or cavity inside the web, which extends vertically toward the head and base of the rail.

- This type of defect is seldom found in modern rail in an advanced stage.

The original seam does not generally grow either vertically or horizontally. However, heavy loads may eventually cause it to spread or open up in a crosswise direction, so as to cause a bulge in the web. Internal seams that might cause little or no trouble under normal traffic conditions tend to open when subjected to pressure butt-welding.

Piped rail is a serious defect because:

- Rail is weakened for the distance of the pipe.

The head is not properly supported by the web, where the pipe exists. Upon the failure of service, the rail may break into several pieces.

Split Web

is a lengthwise crack along the side of the web and extending into or through it.

Development of Split Web

Split webs may be caused by a seam in the web or by external damage.

- At times, the cracks may bleed, making the defect more evident.

If the rail is not replaced, the defect will grow, turning upward and downward until a complete break occurs. The growth is usually rapid after the crack extends through the web, and is accelerated by unusual or heavy loading.

The split web is a serious defect because:

- The rail is weakened for the distance of the separation.
- Upon service failure, the rail may break into several pieces.

Web Defects in Joint Area

Joint area web defects are progressive fractures in the web area of the rail at or near the rail end and are generally associated with conditions resulting from bolted joints.

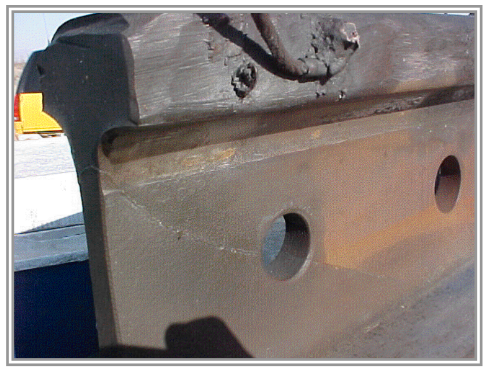
Two types of defects are included in this classification:

- Bolt hole crack
- Head and web separation

Bolt Hole Crack

**i**s a crack across the web, originating from a bolt hole, and progressing on a path either inclined upward toward the railhead or inclined downward toward the base. Fully developed bolt hole cracks may continue horizontally along the head/web or base/web fillet, or they may progress into and through the head or base to separate a piece of the rail end from the rail. Multiple cracks occurring in one rail end are considered to be a single defect. However, bolt hole cracks occurring in adjacent rail ends within the same joint must be reported as separate defects.

Development of Bolt Hole Cracks



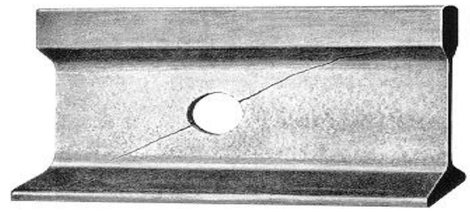
Bolt hole cracks are, of course, not visible until a bolt or the joint bar is removed, unless the defect has progressed above the joint bar and through the railhead or below the bar and through the base.

- After removal of the joint bar the defect may be recognized by a hairline crack extending from the bolt hole for the length of the defect.

Bolt hole cracks frequently result in a piece of the railhead breaking off within the limits of the joint bars.

- Occasionally, the cracks may progress beyond the joint bars and cause a complete transverse separation.

A bolt hole defect originates at a bolt hole and usually progresses at an angle. However, with current high axle loads and special rail steels bolt hole defects can be somewhat perpendicular out of the second and/or third bolt holes.



Bolt hole breaks are also developing on a somewhat horizontal plane particularly with respect to switch point heel joints, frog wing rails, railroad crossing rails, etc.

The growth of the bolt hole defect is erratic when compared with the predictable development of transverse defects in the railhead.

Head and Web Separation

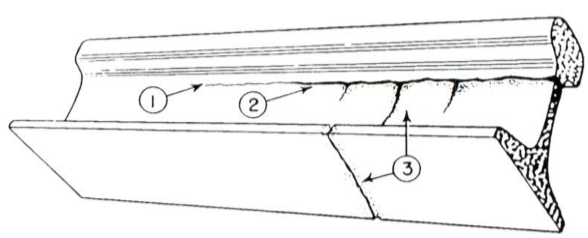
is a progressive fracture, longitudinally separating the head from the web of the rail at the head fillet area.

Acid action from some paving materials used at hi-rail accesses may start corrosion fatigue where the railhead joins the web.

Gravel at crossings, excessive speed on curves, or improper canting of the rail can cause unusual loading of the railhead.

- Fatigue then appears as rail strain, or a creped (wrinkled) fillet under the head.

1) extend downward Characteristics of a head and web separation in track from the longitudinal separation through the web, and In earlier stages wavy, wrinkled lines appear along the fillet under the head.
2) As the condition develops, small crack *will* appear along the fillet on either side, indicating growth through the web. It progresses longitudinally with slight irregular turns upward and downward.

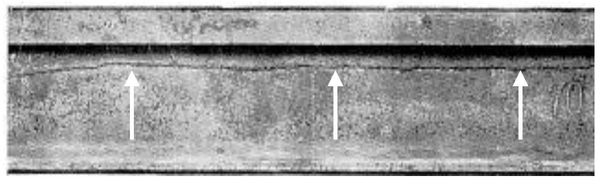


3) In advanced stages. Bleeding cracks will or may extend through the base.

Development of Head and Web Separation

The growth usually occurs in gradual stages but can develop quite rapidly under extreme stress conditions often created by pumping or swinging joints.

- The growth is also rapid once the rail has been turned, as this moves the loading point to the opposite side of the head with the joint bars.



The head and web separations will appear as a hairline crack along the head fillet once the joint bars have been removed. With the joint bars in place, visual detection is not possible until the defect has reached an extremely advanced stage of development.

Head and web separation frequently occurs at hi-rail accesses where visual inspection is impossible. The separation occurs at hi-rail accesses because of the two different forces that are placed on the rail head.

- One of these forces is the load placed on the rail by the train
- The second is the force place on the rail head by the vehicles using the access.

Head and web separation is a serious defect because:

- The entire length of rail is greatly weakened for a distance in excess of the progressive separation.
- In the event of service failure under traffic, the rail is likely to break into several pieces.

F. Base Defects

A base defect is any progressive fracture originating in the base of the rail. This general classification covers two types of defects that can be identified in track:

- Broken base
- Base fracture

Broken Base

is any break in the base of the rail.

Development of Broken Base

A broken base defect is a progressive fracture in the base of the rail, with a vertical separation or split.

- The separation is substantially longitudinal, but usually turns out to the edge of the base. These separations are often called half-moon breaks.

Bearing on ties or tie plates or rail fasteners may cause the separation, or it may originate in a seam, segregation, or inclusion.

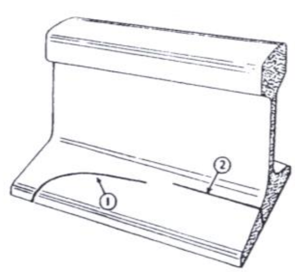
- The growth depends on the location of the break and the loading of the rail.

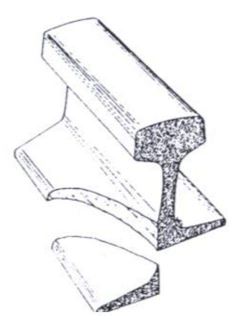
General appearance of a Broken Base

1) A crack starting near the junction of the base and web and extending outward to the edge of the base
2) A longitudinal crack extending along the junction of the web and base
3) A half moon break in the base of the rail.

The broken base is a serious *defect because:*

1) Remainder of the rail cross section becomes weakened
2) Upon complete failure, the rail may break into several pieces





Base Fracture

A base fracture is a progressive fracture in the base of the rail that develops substantially in a transverse plane.

These defects, as a rule, originate on the outer edge of the base.

A nick or blow on the edge of the base that results in an indentation or step usually caused the base fractures.

- Improper rail handling sometimes causes damage of this nature.

Base fractures fall within the FRA definition of broken base.

Base fractures are visible as cracks for the extent of the progressive development into the rail. However, these defects are seldom found visually since a complete rupture usually occurs from a relatively small defect.

- The base fracture is a serious defect because of service failure that is usually a *complete break* of the rail across head, web and base. Also, failure *frequently occurs* before the defect can be discovered visually.

Damaged Rail

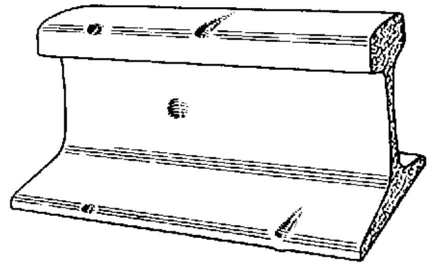
is any rail broken or inferred by wrecks, broken, flat, or unbalanced wheels, slipping, or similar causes.

Possible occurrences of Damaged Rail

One result of external damage can be a sudden rupture of the rail in the transverse direction.

- It is similar to the ordinary break, except that the break can be attributed to some event that caused it.

Another type of damage may produce kinking of the rail. Kinked rail is not considered to be serious from the standpoint of possible failure but continued use can create maintenance problems.



Another form of damage consists of nicks in the rail.

- Nicks can cause the development of defects.
- The likelihood of this happening is dependent upon the depth, sharpness, and location of the nick.

Track workers carelessly using a spike maul while spiking, or striking the rail while adjusting expansion may cause some nicks. Other nicks on the head of the rail are caused by broken wheels and these could be serious.

- When this occurs a qualified inspector should examine the rail and determine whether or not the rail should be replaced.

G. Defective Welds

is a field or plant (shop) weld containing any discontinuities or pockets, exceeding 5 percent of the rail head area individually or 10 percent in the aggregate, originated in or near the transverse plane, due to incomplete penetration of the weld metal between the rail ends, lack of fusion between weld and rail end metal, entrainment of slag or sand, under-bead or other shrinkage cracking, or fatigue cracking. Web defects may originate in the rail head, web, or base, and in some cases, cracks may progress from the defect into either or both adjoining rail ends.

A defective weld is most frequently a transverse defect, but sometimes, it is a longitudinal or split web type of defect, which can grow until complete failure occurs. Foreign matter on the faces of the rail ends can cause it at the time of welding, by incomplete fusion during welding or by cracks caused by the heating of the rail during the welding process.

- The defect may be in the head, web, or base of the rail.

Defective plant weld

A defective plant weld may be a progressive transverse defect in the railhead within the area where two rails have been joined by a pressure welding process.

Defective plant welds may be caused by slag inclusions, oxide entrapments, improper fusion during the welding process, or thermal cracks that can result from rapid or otherwise improper cooling.

Web defects on a longitudinal plane through the weld may result from stress risers at shear drags, grinder gouges or residual stresses in rail ends prior to welding.

- Growth of a progressive head weld defect is normally slow.

Ruptures of improperly fused welds or other gross weld imperfections will usually occur in handling or when initially exposed to traffic.

Technical Training

Track & Structures

Track Inspection Training

Turnouts

Section 8

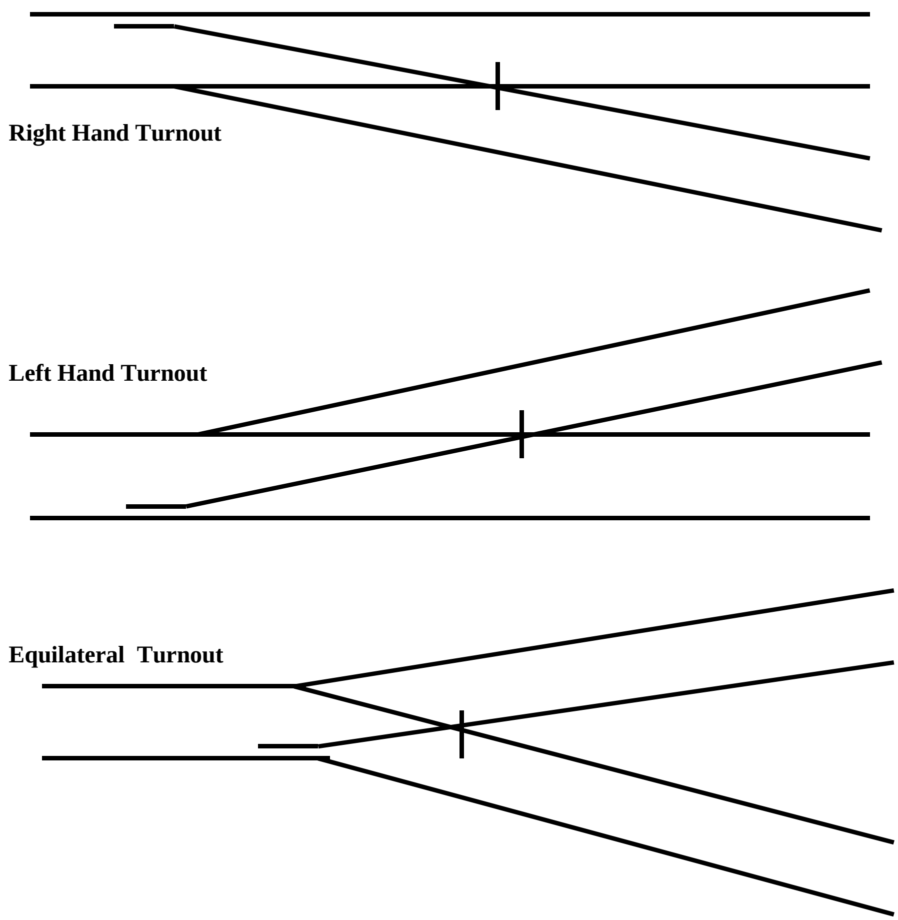
TURNOUTS

It is necessary to have a good understanding of what is meant by the words turnout and crossover. The easiest way to do this is by looking at diagrams.

It is entirely possible that you may be in the habit of referring to a turnout as a switch.

This is a fairly common practice but it is not accurate.

A switch is part of a turnout.



The switch consists of two switch points (or switch rails) Plus the fittings needed to hold them in position.

A turnout consists of a:

a) Switch

b) A frog

c) Connecting closure rails.

d) Together with the necessary timber and other parts needed to complete both routes.

A. DETERMINING TURNOUT DIRECTION

It can be seen that the way to determine whether a turnout is right hand or left hand is to stand at a location ahead of the switch points and look toward the turnout (the frog).

- From this location the curved side of a right hand turnout will go to your right.
- The curved side of a left-hand turnout will go to your left.

Facing Traffic

While standing in this position and looking toward the turnout, you are looking in the direction in which a train or other equipment makes a facing movement.

This applies regardless of whether the switch is set for a straight-through movement or for movement to the reverse or curved side.

The straight route might be referred to as the **facing normal** or **normal**, the **main route** or the **straight side** depending on the location of the turnout.

The curved route through a turnout is frequently referred to as the **facing reverse** or **turnout side.**

Trailing Traffic

Now suppose you were to go to the other end of the turnout and turn around so that you will again be looking at the turnout (the frog).

From this position you are looking in the direction in which a train or other equipment would make a trailing movement through the turnout.

- This would apply to movements from either the straight side or the curved side.

Equilateral Turnout

The less-frequently-used **equilateral turnout** might be found at a location where two main tracks converge into a single main track or where two mainline tracks diverge into a **pocket track**.

- The equilateral turnout splits the curvature between both sides.
- Neither route has the unrestricted speed that the straight side of a turnout would have.
- But both routes have less of a speed restriction than the turnout side of a right or left-hand turnout would have.

B. FROG

Behind the frog of a turnout, one of three things can happen:

a) The turnout track can curve back to parallel the main track The turnout track can continue to curve away from the parent track.

b) The turnout track may continue at the same angle as the frog.

In a crossover, the track between the two frogs follows the frog angle.

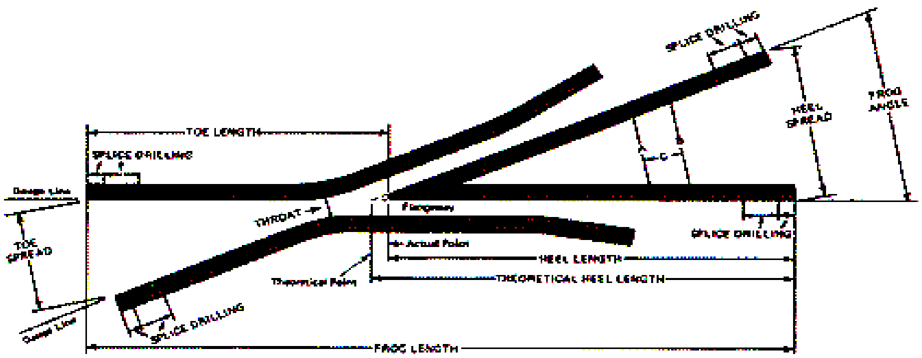
- The timber layout for half of a crossover will be different from that of a turnout.
- Except for these minor limitations, a crossover might be considered as two turnouts.

LET S LOOK AT THE FROG

The first part of the turnout structure that will be considered is the frog.

A **frog** is a device that permits flanged wheels running on a rail to cross another running rail.

Every turnout must have a frog.

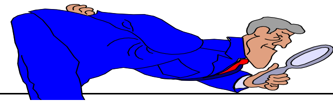


In addition, turnouts are classed as to size by the frog.

In determining where a turnout is to be located, it is the position of the frog that is determined first.

All other parts of the turnout are then located relative to the position of the frog.

Some turnouts are designed for operating trains on both routes at substantial speeds.



- Others, such as a spur off a main-line track, are designed for high-speed operation on one route and low-speed on the other route.
- At other locations, such as in yards, they are designed for low-speed-operation only.

Turnouts of various types and sizes are available to meet the requirements of local conditions. The size of a turnout will be considered first.

Turnout Size

The sizes are usually stated as a whole number.

Some of the more frequently used turnouts are the # 6, # 8, # 10, # 12, # 15 and # 20.

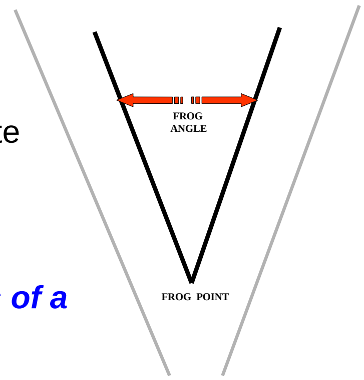
Here at MARTA we u se;

- No. 6 turnout (1 only at Canterbury, FR Track into the storage track).
- No. 8 turnouts (Avondale Yard, South Yards, Armour Yard and equilateral switches).
- No. 10 turnouts (Mainline).
- No. 20 turnouts (Avondale, Ashby and Canterbury).

Quite a few other sizes are sometimes used, but on most transits and railroads some or all of the above sizes are commonly used.

Frog Angle

Actually, these numbers refer to **the frog angle.**



It is because the frog angle is so important in determining the size of the turnout that this designation is used to indicate the size of the turnout.

The frog angle is the angle between the two gauge lines of a frog.

All track personnel should know how to measure a frog angle.

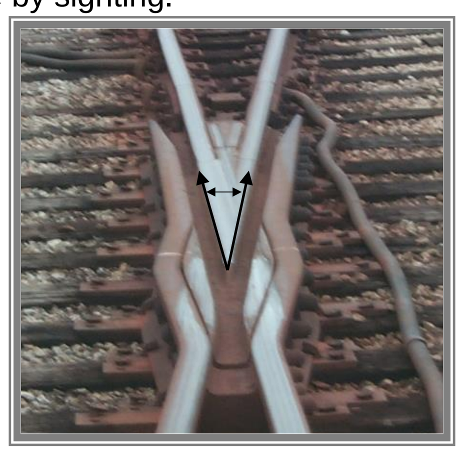
a) The first thing to find is the intersection of the two gauge lines, brought forward from the point portion of the frog.

b) The actual point of the frog is blunt.

- If the frog were constructed with the actual point brought forward to the intersection of the gauge lines, the point would come to a knife-edge and would quickly break off under traffic.

c) Determine where the gauge lines come together.

- This can be done with a straight edge or a piece of string.
- If there is not much wear it might be done by sighting.
- It does not have to be highly accurate.



d) Mark the location.

- If you are within an inch of the right point, that's good enough.

e) Next, you will need something to measure with.

- Anything of a convenient fixed length will do.
- You can use a pencil and measure in pencil lengths.

Let's assume you have a pocket ruler.

f) Go back on the point of the frog and find where the distance between the two gauge lines is exactly one foot.

g) Now, mark the point of this line midway between the gauge lines.

h) Next, measure the distance from that point to the point you located at the intersection of the gauge lines.

- Let us suppose it is 8-feet. This tells you that it is a No. 8 frog.
- Possibly you have measured 7' 11-1/4", or perhaps 8' 1-3/8". You still have a No. 8 frog, because your method of measuring is not that accurate, and most frogs are built to whole numbers.
- However, if your distance is about 7' 6-1/2", you had better re-measure more carefully. It might be a No. 7 frog.

Try another example.

Locate the intersection of the gauge lines the same way.

a) This time in determining the spread, you find that you would have to go back a long way to find a **<u>one-foot spread</u>**.

b) Take a more convenient unit.

c) A six-inch spread will do.

d) After locating the point midway between gauge lines on the six-inch spread; measure from there to the intersection point, which you located first.

- Suppose it comes to about ten feet.
- Remember that you are no longer using one-foot units.
- This time you are counting six-inch units.
- Ten feet is 20, six-inch units.
- So this is a No. 20 frog.

Maybe you had to use a pencil. You find the location where there is a spread of one pencil length. Then count ahead in pencil lengths to where the gauge lines intersect.

- The number of pencil lengths will tell the frog number.

C. SIZE AND FROG NUMBER

1) The smaller the frog number, the larger the frog angle will be.
2) The larger the frog angle, the sharper the curve will be through the turnout.
3) The sharper the curvature, the lower the maximum permitted speed will be.

For example,

1. A No. 20 turnout is usually found in main tracks where substantial speeds are required on both the straight side and the turnout side.
2. A No. 10 turnout if well maintained will permit high speeds on the straight side but only low speeds (25 mph or less) on the turnout sides.
3. A No. 8 turnout (found in the yards) if well maintained, will permit high speeds on the straight side but only low speeds on the turnout sides.

Point of Frog

It has previously been stated that the point of a frog is somewhat blunted so that it does not break off under traffic.

- The location where the frog point ends is called the **actual point.**
- The intersection of the gauge lines, which has also been described, is also known as the **theoretical point** of the frog.
- The theoretical point, in addition to its importance in determining the number of a frog, is of value to surveyors in determining the proper location of a turnout.

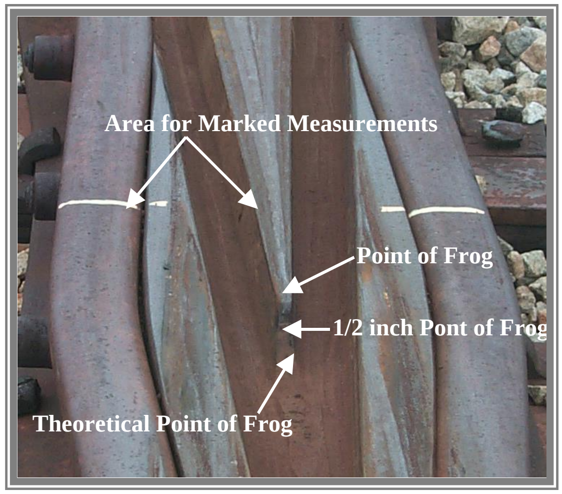
Half Inch Point

There is another frog point, which you need to be familiar with. This is the so-called **half-inch point.**

This is usually located a short distance ahead of the actual point and on most frogs is identified with a chisel mark.

It is so named because it is at the location where the gauge lines on either side of the frog point are one half inch apart.

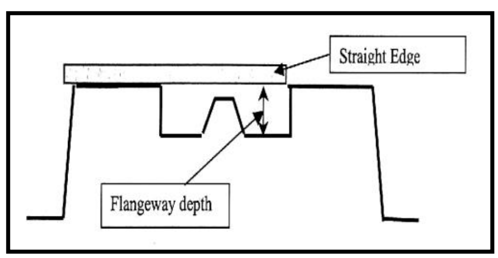
- It is from the half-inch point that most distances that you will have to work with are taken.



The two legs of the frog closest to the switch are known as **the toe of the frog.**

- The two legs of the frog furthest from the switch are known as **the heel of the frog.**
- The toe length and heel length of a frog, are measured from the half inch point to the end of a toe or the end of a heel.

RAIL BOUND MANGANESE STEEL FROG (MARTA)



A cross-sectional drawing would show the central manganese steel casting as well as the surrounding tee rails from which the term **rail bound** is taken.

- This type of frog is suitable for high-speed, heavy-tonnage main-line use.

In addition to providing protection for the frog point against being struck by a wheel flange, all types of frogs, which have been described, are designed with provision for avoiding the placement of the full weight of a heavily loaded wheel on the relatively narrow portion of the point close to the tip.

This is done in one of two ways

a) One is to manufacture the frog with the portion of the wings adjacent to the throat of the frog, and for several inches behind the actual point, slightly raised above the plane of the point.

- This procedure sometimes results in these wings being referred to as **risers**.

b) The other alternative is to manufacture the frog with the first several inches of the frog point slightly depressed below the plane of the wings.

Frog Flangway Depth

a) The flangeway depth measured from a plan across the wheel-bearing area of a frog on Class 1 track may not be less than 1- 3/8", or less than 1 ½" on Classes 2 through 5 track.

b) If a frog point is chipped, broken, or worn more than 5/8" down and 6" back, operating speed over the frog may not be more than 10 mph.

c) If the tread portion of a frog casting is worn down more than 3/8" below the original contour, operating speed over that frog may not be more than 10 mph.

d) *Where frogs are designed as flange bearing, flangeway depth may be less than that shown for Class 2 if operated at Class 1 speed.*

D. PURPOSE OF GUARD RAILS

It has already been shown that a wheel moving through the open flangeway of a frog must be guided along the proper route.

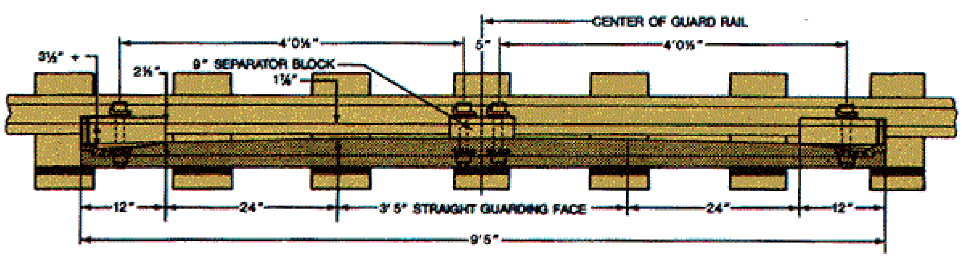
On all frogs, other than self-guarded frogs, this is done by means of guardrails.

- Guardrails must be provided on both the straight and turnout sides.
- Guardrails guide wheels moving through a frog throat by applying pressure to the back of the flange of the wheel on the other end of the axle.
- The restraint is therefore transmitted through the entire assembly of both wheels and the axle.

Types of Guard Rails

There are several kinds of frog guardrails in general use. Most of them can be grouped in one of two general types.

a) One is the type fastened directly to the running rail, using either bolts or clamps with spacer blocks. These are usually made of tee rail with the ends flared and tapered. (this is the type that we use here on MARTA mainline tracks)



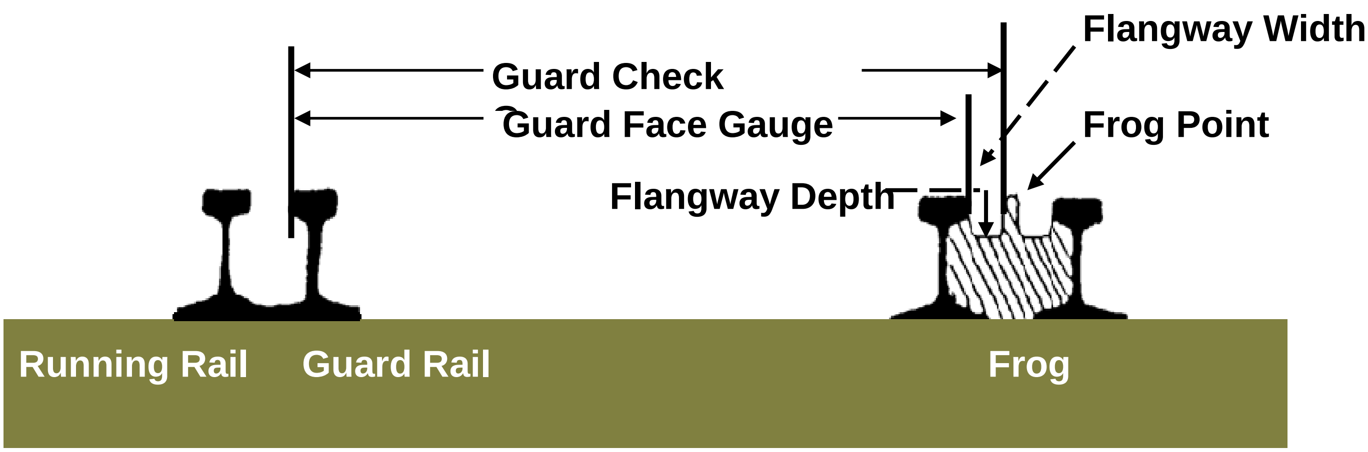
b) The other type includes base plates permanently attached to the guardrail. These base plates, generally, extend under the running rail serving as tie plates for the running rail.(this is the type we use here at MARTA on the yard tracks)

- An advantage of this construction is that when the guard rail is called upon to provide lateral restraint to a wheel, the weight of that wheel load is being transmitted through the running rail to the guard rail base, helping to keep the guard rail from moving.

Also, there may be more than one length of frog guardrail provided to meet certain conditions. These you must determine so that you will be prepared to install and maintain guard rails in accordance with your company's requirements.

Guard Rail Measurements

New guardrails are securely fastened to 1 7/8” flangeway opening. The guard-check and guard face gauges in frogs must be within the limits prescribed in the following table.



Check location of guardrail in relation to frog point to insure that the open area ahead of the point is protected by the straight portion of the guardrail.

The minimum length of straight guarding face should be, in inches; two times the frog number for rail bound frogs and 40 inches for spring frogs.

A minimum of 6 inches straight guarding face is required following the frog point.

E. EXAMINING A SWITCH

The next part of the turnout that will be considered is the switch.

It has already been shown that the switch is made up of a number of parts.

The two largest parts are the switch points.

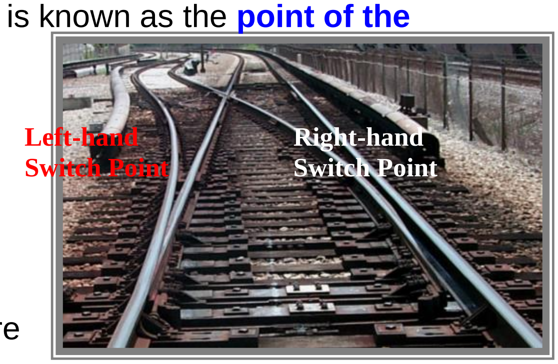
Every switch has a right-hand and a left-hand switch point.

a) To determine the hand of a switch point, stand in the center of the track at a point ahead of the switch.

b) Look toward the switch (this will be in the direction of a facing train movement). The right-hand switch point will be to your right and the left-hand switch point will be to your left.

c) The thin, tapered end of a switch point is known as the **point of the switch**.

d) The other end of the switch point, with the full tee rail section, is known as the **heel of the switch**.



A switch point is the means by which wheels are diverted from the rail on which they have been running to another route.

To do so, the shape of the point of the switch and the manner in which it fits against the adjacent rail (stock rail) must be designed and maintained within rather close limits.

A switch, which has an exposed point that the flange of a wheel may strike, (during a facing movement) presents a very real danger of derailment, should a wheel flange climb onto the top of the switch point.

- Such an exposed point can be due to improper fit between the switch point and the stock rail.

- A gap as little as ¼" can cause the wheels of a train to **pick** the point and cause a derailment.

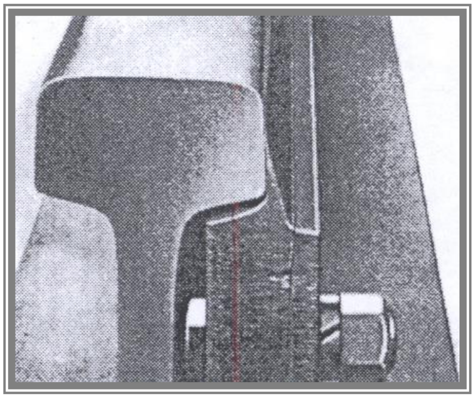
A point which is too thin may not have enough strength to withstand loads placed upon it, nor would it have a reasonable life under traffic conditions which cause wear on the switch point.

On the other hand, a thickly constructed switch point may present a blunt point for the wheel flanges to strike.

In any switch, one switch point will be used by traffic using one route through the turnout, and the other switch point will be used by traffic on the other route.

Switch Points

a) Each stock rail must be securely seated in switch plates, but care must be used to avoid canting the rail by over tightening the rail braces.
b) Each switch point must fit its stock rail properly, with the switch stand or switch machine, in either of its closed positions to allow wheels to pass the switch point.



c) Lateral and vertical movement of a stock rail in the switch plates or pads or of a switch plate or pads on a tie must not adversely affect the fit of the switch point to the stock rail.
d) *Broken or cracked switch point rails will be subject to the requirements, except that where remedial actions C, D, or E require the use of joint bars. Joint bars cannot be placed due to the physical configuration of the switch, remedial action B will govern, taking into account any added safety provided by the presence of reinforcing bars on the switch points.*

e) Each switch must be maintained so that the outer edge of the wheel tread cannot contact the gage side of the stock rail.

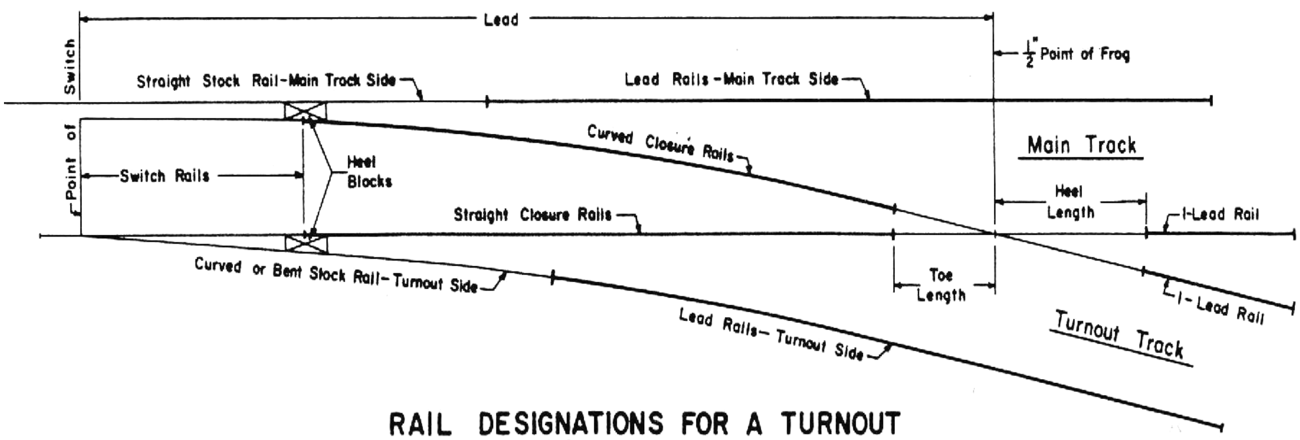
f) The heel of each switch rail must be secure and the bolts in each heel must be kept tight.

g) Each switch stand (or switch machine) and connecting rod must be securely fastened and operable without excessive lost motion.

h) Each throw lever must be maintained so that it cannot be operated with the lock or keeper in place.

i) Unusually chipped or worn switch points must be repaired or replaced. Metal flow must be removed to insure proper closure.

Look at the Remedial Action Table for correct action to be taken if any of these problems occur.



RAIL DESIGNATIONS FOR A TURNOUT

(RIGHT HAND TURNOUT-AS SHOWN)

Heelblock

As a switch point is moved between these two positions, it pivots about a joint at the heel of the switch point.

This heel joint acts somewhat like a hinge.
In some cases the heel joint is an ordinary rail joint, connecting the switch point to the closure rail.

The preferable arrangement for heavy-duty use and the one we use here at MARTA, includes a heel block, which is inserted between the heel joint and the stock rail, through which both the heel of the switch point and the closure rail are bolted to the stock rail.
A standard joint bar may be used on the field side of the stock rail in a heel block joint.

A special bent bar is used on the gauge side of the switch point and closure rail to permit the movement of the switch point.

It should be recognized that there is a minimum practical distance between the gauge line of the stock rail and the gauge line of the switch point at the heel of the switch.

This is determined by the width of the head of the switch point.

And the need to keep an adequate flangeway opening between the stock rail and switch point for wheels moving on that route.

When a set of wheels, in which the axle moves through the straight side of a turnout and that turnout is on tangent track.

- The switch point which one wheel moves on, and the stock rail, which the other wheel moves on, are both a continuation of the straight line of the tangent.

The wheels undergo no change of direction. Practical speeds are limited only by the quality of the maintenance.

- The length of the switch point on this route is not particularly critical.

F. CHANGING WHEEL DIRECTION

When a wheel set moves through the other side of a switch, leading to or from the turnout side, the wheels do undergo a change of direction.

- A change of direction does impose restrictions on speeds that can be permitted.
- The extent to which speeds must be restricted depends on how abrupt the change of direction is.

Two things, which determine the abruptness of the change of direction, are:

a) The spread between gauge lines at the heel of the switch.
b) The distance between the point of the switch, and the heel of the switch.

Length of Switch Point

The distance between these points is the length of the switch point.

A deflection from a straight line of 6-1/4", which is the standard heel spread for switches built to the designs recommended by the American Railway Engineering Association. And occurring within the length of a 16-foot 6 inches (#8) switch point will be more abrupt than a similar deflection occurring in the length of a 39-foot (#20) switch point.

- Thus, it can be seen that relatively long switch points are needed in order to permit substantial speeds on the turnout side.
- The length of the point on the straight side is not important from the standpoint of speed.

However, if both switch points in a turnout were not of the same length, it would not be possible to maintain uniform gauge through the turnout side of the switch.

Consider a switch point on the turnout side, which has a straight gauge line throughout its length.

- The change in direction occurs suddenly, at the point of the switch.
- On the other hand, if this switch point is provided with a curved gauge line, the change in direction is more gradual.
- The change of direction is continual throughout the entire length of the switch point and less severe at any one point.

Because of this, **ALL** switches at MARTA are designed with a curved gauge line on the straight side.

Turnout No.	#8	#10	#15	#20
Length of Switch Point	16'-6"	19'-6"	26'-0'	39'-0"

G. THE STOCK RAIL

The next part of the turnout structure that will be examined is the stock rail.

The stock rail is the conventionally shaped tee rail against which the switch point fits, when the point is in the closed position.

When the switch point is in the open position, the stock rail is part of the route on which the wheels travel instead of the switch point route.

Each switch point must have a stock rail; therefore, each turnout must have two stock rails.

Stock rails are designated as right-hand or left-hand in the same manner as switch points.

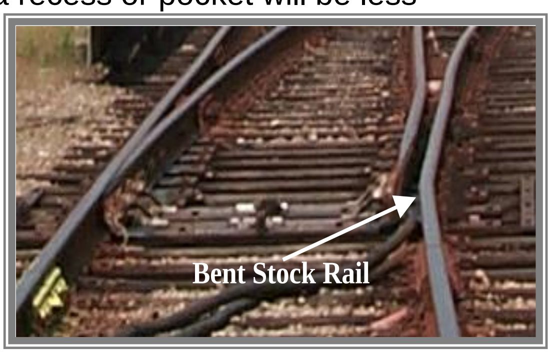
- A straight stock rail is used on the straight side of a turnout.
- A curved stock rail on the curved or turnout side.

a) To provide a good fit at the point of the switch, so that an exposed point will not be available for wheel flanges to strike on facing movements.

- To do this properly, a full contour on the head of the stock rail is needed.
- A worn railhead will not adequately protect the switch point.
- In most cases when a switch point needs replacement, ***the stock rail should also be replaced.***
- It is not good practice to place a new switch point against even a moderately worn stock rail.
- It should be remembered that a switch point is usually a much more costly piece of track work than a stock rail and that the emphasis should be on attaining maximum useful life from the switch point.

b) Provide a recess in the gauge side of the stock rail.

- This is limited to the portion of the stock rail with which the switch point makes contact. It is sometimes done in a shop, usually by planing.
- In other cases, it is accomplished on the ground, usually immediately after installing a stock rail in track.
- In such instances, it is usually done with a grinder.
- A switch point which fits into such a recess or pocket will be less exposed to an oncoming wheel flange at the tip of the point.

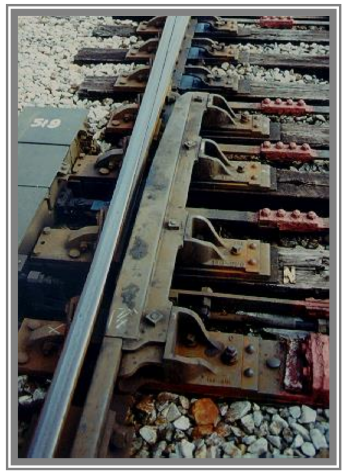


c) Another way in which the point of a switch is protected from wheel flanges, is by bending the stock rail a short distance ahead of the point of the switch.

- This is commonly done to the stock rail on the turnout side, which, is matched with the switch point on the straight route.
- It is not done with the stock rail on the straight side.

H. RAIL BRACES

Another important function of the stock rail, in relation to the switch point, is one of support.



Since a switch point can only be used when in the closed position, the lateral support provided by the gauge side of the stock rail bearing against the back side of the switch point is an important part of the total support of the switch point.

Certainly, the stock rail must be able to provide substantial support for the switch point, one complicating factor in this, is that the base of the gauge side of the stock rail cannot be spiked or clipped within the limits of the switch point.

- This is because of lack of clearance between the switch point and the stock rail, in the closed position.

To overcome this problem, additional support is provided to the field side of the stock rail by means of braces

- Such braces are fastened to switch pads or switch plates and bear against the web of the stock rail.
- In some cases they also bear against the underside of the railhead.

In this manner, considerable resistance is developed against any tendency for the stock rail or the switch point to be rolled over.

While it may not be so in some older designs, most modern types of stock rail brace are adjustable. This aids in setting the stock rail so that a good bearing can be had with the switch point throughout the entire intended contact area.

I. SWITCH POINT PROFILE

We have seen how switch point, stock rail installations must provide protection against potential hazards that could exist for equipment moving in the facing direction.

Movements in the trailing direction are not, without the potential for a hazardous condition either.

- Consider a switch point and a stock rail which fit well, but in which the head of the switch point throughout its length is slightly lower than the head of the stock rail.

Gap at both switch points will de-rail a train

As a wheel moves along the switch point in the trailing direction, from the heel toward the point, as the outer edge of the wheel rim first makes contact with the stock rail, the wheel probably will not climb up onto the head of the stock rail.

Instead, the wheel might very well stay inside the gauge side of the stock rail, forcing the stock rail to be spread away from the switch point.

This would almost certainly result in a derailment.

If both the stock rail and the switch point were at the same level, this probably would not happen.

But suppose the head of the switch point acquired **more wear than the stock rail,** or **suppose a badly worn wheel** were to make such a movement.

- The wheel might have more tread wear close to the flange than at the outer edge of the tread.

In either case the results could be the same. The stock rail could be forced to the field side, resulting in a derailment immediately ahead of the switch point.

The way to protect against this hazard is to provide for the head of the switch point to be **raised higher** than the head of the stock rail, in the area where wheels make this transition from the switch point to the stock rail, on trailing movements.

- To do this, switch points are bent vertically in manufacture.

Remember: that it is equally important for the point of the switch (first 6 to 8 inches) not to be higher than the stock rail because of the dangers of point breakage and wheel climbing in facing movements.

J. SPECIAL PADS AND PLATES UNDER POINTS

This vertical shaping would be of no value if matching support were not provided for the base of the switch point.

If the switch pads or plates provided the same level of support for the switch point that they did for the stock rail, the weight of traffic would soon remove the vertical contour of the switch point.

Examine a set of switch pads or plates carefully. If possible look at both a set of pads or plates which are in track and a set which are stock piled.

You will be able to see that there is a variety of pads or plates with different relative elevations provided for the switch point and stock rail. The usual difference in elevation at the maximum point is 1/4-inch.

At this point it should be noted that there are two basic types of switch point riser design in use. Some railroads use only one type; others use both types.

The two designs are generally similar between the point of the switch and the point of maximum riser height.

- It is behind this point that the difference in design occurs.

If the difference in elevation is run out within the limits of the switch point (which means that the stock rail and switch point are at the same elevation within the heel block), the switch is said to have graduated risers.

However, if a less sudden change in elevation is desired for a smooth ride at high speed, then this difference in elevation can be run out behind the heel block on the closure rails.

This design requires special switch plates under the portion of the closure rails within the limits of the run-off. A switch so designed is said to have **uniform risers**.

MARTA uses only the UNIFORM RISERS system.

The turnout pads or plates shown behind the left-hand heel block are typical of those used with a switch having uniform risers.

The pads shown behind the right hand heel block are typical of those used with a switch having uniform risers.

K. SWITCH ROD ARRANGEMENT

At this point, we should direct our attention to some of the other fittings within a switch.

In the operation of a switch, it is highly desirable to have both points move in unison, that is, as one point is being closed, the other is being opened.

- Without such an arrangement, there would be opportunity for error in aligning a switch.

A derailment can occur with both points in the open position or with both points in the closed position.

Switch rods are used to connect the right and left-hand switch points so that one switch point cannot be operated independently of the other.

1. Switch Rods

The switch rod, which is located closest to the point of the switch, is called **the No. 1 rod**.

Each rod in order, moving towards the heel of the switch is numbered according to its position. A short switch may only have two rods; longer switches will have additional rods.

The designations such as;

- # 3 switch rod
- #2 switch rod
- #1 switch rod

A No. 4 rod, for example, should not be used in the No. 2 position because the hole drilling would be wrong.

1 Switch Rod

The No. 1 rod is usually distinctively different from the other switch rods.

- The reason for this is that there is another rod, which is connected on one end to the No. 1 switch rod.
- The other rod is not called a switch rod; it is an **operating rod.**
- The end of the operating rod, which is not connected to the switch rod, is connected to whatever type of mechanism is provided for moving the switch from one position to the other.

- The necessary thrust for throwing the switch is transmitted through the operating rod to the No. 1 switch rod, and through the No. 1 rod to the switch points themselves.

Other Throw Rods

On some of the longest switch points, there will be a switch rod, which looks similar to the No. 1 rod, located somewhere about midway between the point and the heel of the switch.

- This switch rod will have a rod or arrangement of rods connected to it and to a power source, which provides assistance in throwing such long switch points.

It is not practicable to connect switch rods directly to the switch points. This is accomplished through an intermediate fitting known as a **switch clip or side-jaw clip.**

In a typical switch clip, the bolts, which fasten a switch clip to a switch point, are known as **switch clip bolts**.

The bolts, which connect a switch rod to the switch clips, are known as **switch rod bolts.**

Sometimes an alternative arrangement is used to connect the switch points to the switch stand or switch machine.

Instead of providing an operating rod, which is connected to the switch stand or switch machine on one end and to the middle of the No. 1 switch rod on the other end, 4' a shorter rod is used which makes a connection between the switch stand and the switch clip that is closest to the switch stand.

Such a rod is known as a **connecting rod,** rather than an operating rod.

These installations are generally limited to slow speed territory on railroads, which use this arrangement.

You may find cases in which there is another difference in types of switch rods. If the width of a switch rod is greater than its height, it is known as a **horizontal switch rod.**

In such rods, the switch rod bolts are installed in a vertical position. If its height is greater than its width, it is a vertical switch rod.

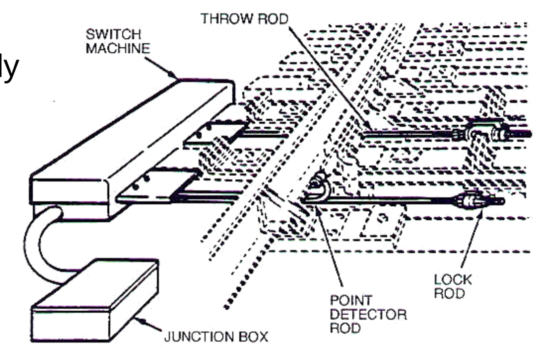
Such rods require a different type of switch clip and the switch rod bolts are installed horizontally.

L. COOPERATE WITH SIGNAL FORCES

Mention has already been made of the necessity of some sort of mechanism with which to throw the switch from one position to the other and back again.

There are various ways in which such devices can be classified.

- At some important locations power operated machines are used. The installation and maintenance of such equipment is usually the responsibility of A.T.C.
- All switches are operated mechanically here on MARTA mainline tracks.
- The only exceptions are in the rail yards.



But all MARTA Mainline and Yard switches can be manually operated with permission from Rail Control or the Yard Tower Supervisor.

If they are on Mainline track, A.T.C. forces will again be involved in the functioning of the switch operating mechanism. (switch machine)

As there are differences in the extent of the responsibilities of The Track Department and the A.T.C. Department, it is necessary that you determine what the agreed upon practice is in your area.

One thing is certain; there is always a need for close cooperation between these two crafts in such work.

Usually, the devices used for operating them are exclusively the responsibility of the Track Department.

Whatever the case, you should take advantage of opportunities to examine such switch stands closely, ask questions of employees experienced in maintaining them, and become knowledgeable in their care.

Switch Calls

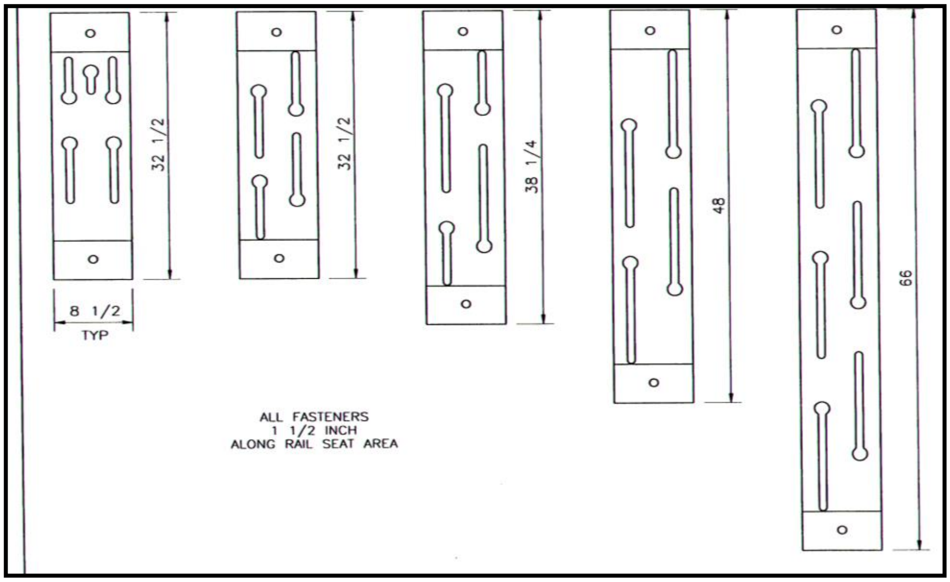
A switch call positions a switch in either the normal or the reverse position. Switch calls can be made by the route logic, Rail Control or the local control panel.

Switch calls are executed only if the switch in the unlocked condition. If locked, the switch will remain in the locked position.

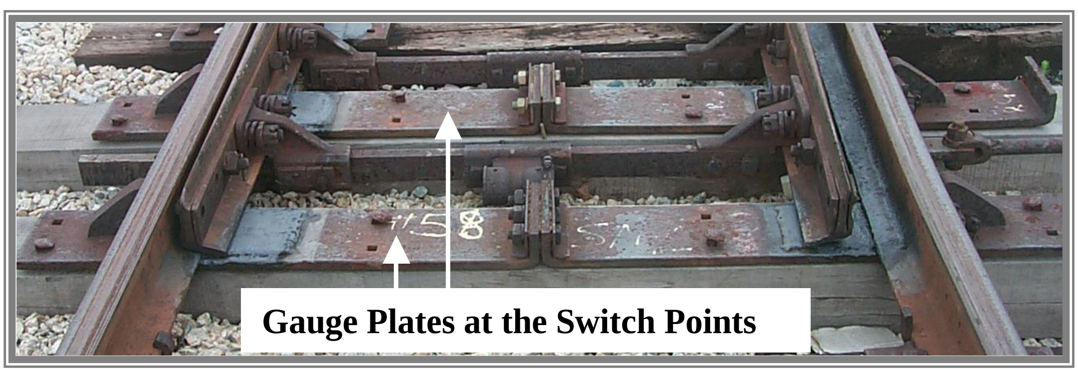
M. Special Plates

A number of different types of pads or tie plates are required under various parts of a turnout.

Special pads or plates are required under the frog guardrails and adjacent running rails, if the guardrails don't have integral plates.



We have seen how special switch pads or plates are required under switch points and the adjacent portions of the stock rails.



Gauge Plates at the Switch Points

Some types of frogs may have integral tie pads or plates, but many frogs do not.

N. RAIL AND RAIL JOINTS

This lesson has been concerned mostly with special track work parts used in turnouts and crossovers.

Conventional track materials, such as

- Standard tie plates or pads
- Joint bars
- Spikes
- Bolts
- Rail anchors
- Ballast

Some attention should be given to the use of rail within turnouts and crossovers.

The balance of the rails used within turnouts and crossovers do not need special preparation, but the location of joints connecting these rails requires careful attention.

A list of several facts and desirable goals regarding the location of joints within turnouts and crossovers would include the following:

1. It is necessary to install insulated joints in turnouts and crossovers located within the A.T.C. circuits.
2. Insulated joints must be located with a minimum stagger distance because of electrical requirements.
3. It is preferable to maximize the stagger of all joints from the standpoint of track stability.
4. It is not practical to locate joints within the limits of frog guard rails or switch points.
5. It is not good practice to have a stock rail terminate in a heel block joint.

It is sometimes desirable to build or replace turnouts with pre-assembled panel sections.

- This type of construction lends itself to minimum stagger of joints.
- It can be seen that some of the above conditions are not compatible with each other.

This leads to a situation where the stagger of joints within turnouts and crossovers is less than desirable.

Many railroads have standard plans for turnouts and crossovers, which among other things show the recommended locations for joints in such track work.

- At MARTA we have criteria for joint locations.

In some cases, pre-cut lead rails of special lengths are available to reduce cutting and drilling of rails on the job site.

You should become familiar with such plans, not necessarily to the extent of learning the various rail lengths and locations, but to the extent of being able to find the needed information when you need to put it to use.

O. TURNOUT CLOSURE RAILS

The rails, which connect the heels of the switch with the toes of the frog, are the closure rails.

- In a right-hand or left-hand turnout, the length of the curved closure will be slightly longer than the length of the straight closure.
- In the case of an equilateral turnout, the two closures will be of equal length.
- In most cases more than one rail will be required to complete each closure.

In A.T.C. circuited territory, an insulated joint will be required at an intermediate point within the curved closure if the normal route of traffic is to the straight side.

In present-day practice, there is a trend toward the reduction in the number of joints in turnouts and crossovers through the use of welded rail.

There can be a good deal of variation in the extent to which this practice is carried out.

In other cases, the effort to eliminate joints may receive equal attention on both routes.

In some instances, joints at the toe and heel of the frog are eliminated through welding.

- Many times they are not welded, and either conventional or adhesive type joints are installed.
- Here at MARTA, we typically use conventional joints or adhesive joints.
- Stock rails may be prepared in a shop, and after installation the ends may be either field welded or connected with joints.
- In other cases, continuous welded rail may be laid through the stock-rail locations.
- The drilling, bending and grinding operations can then be performed in track.

While insulated joints must still be provided at appropriate locations within turnouts and crossovers, the use of the glued type insulated joints greatly reduces the amount of maintenance required.

P. SWITCH TIES

With very few exceptions, switch ties are made of timber. MARTA uses not only standard oak ties they also use Azobe ties.

In constructing turnouts, no two switch ties will have an identical arrangement of fasteners.

The ability of the timber switch tie to be lagged or spiked in whatever locations are required, is a very important factor in favor of this material for use in turnouts and crossovers.

Usually the minimum length is 9-feet, with the increments increasing to about 16-feet.

Ties several feet longer than this are also provided for crossovers, the actual length being dependent upon prevailing track centers.

Turnout and crossover plans usually indicate the number of switch ties required of each length and their location for commonly used track layouts.

The usual practice is to maintain a uniform alignment of switch tie ends on the straight side at a fixed distance from the near rail.

Usually, the greatest care in maintaining spacing between switch ties, as shown on the plan, has to be in the vicinity of the switch and the frog.

- This is due to the need for clearance for the switch rods and clips, and for proper placement of frog guardrails.

A good understanding of the principles of the design of turnouts and crossovers, which this lesson has covered, will benefit you when you undertake the study of these other subjects.

Q. Maintaining Switch Points

The proper maintenance of switch points is one of the most critical jobs associated with the care of turnouts and crossovers.

If a switch point fails to guide every wheel of every train to the proper route, a derailment is practically inevitable.

There are numerous conditions that can develop which may result in a wheel not being directed to the proper route.

There are more potential hazards connected with equipment movements made in the facing direction than in the trailing direction.

Whenever any equipment makes a facing, movement through a turnout, both wheels of each axle are first moving on the stock rails.

- One switch point is in the closed position, and the other switch point is in the open position.
- The flange of each wheel on the side with the closed point must be guided to the proper route by that point.
- It is essential that each wheel flange must contact with the gauge side of the switch point. For this guiding action to take place.

Should a wheel flange make contact with the end of the switch point, rather than the gauge side, trouble will result.

1. One thing that can happen when a wheel flange strikes the tip of a switch point is that it can be deflected so that it goes behind the switch point.
    - If this occurs. The tread of the wheel will continue to ride on the stock rail.

2. When the distance between this stock rail and the other stock rail on which the opposite wheel is riding becomes too great, one or both of the wheels will fall inside a stock rail.(wide gauge)
    - Another possibility when a wheel flange strikes the tip of a switch point is that of the flange climbing onto the top of the switch point.
    - There is a strong chance of derailment occurring, in this situation.

3. A wheel flange that strikes the end of the switch point may still be deflected to the proper route, along the gauge side of the switch point.
    - When this happens, the movement will continue without derailment.
    - However, the impact of the wheel flanges striking the tip of the switch point can cause rapid deterioration of the point.
    - The end of the point can be battered down. Becoming successively more blunt with each impact until the wheel flange does become deflected to the wrong route.
    - A piece of the switch point could break out suddenly; leaving a blunt exposed surface, which a following wheel flange can climb.

4. A wheel flange might strike a switch point because it does not fit tightly against its stock rail.

    - In other words, the switch point is said to be, **gapped**. There are several conditions that can cause this to occur.
        a) Improper adjustment of the operating rod

b) Switch stand or switch machine not securely spiked or lagged to the head block ties
c) Stock rail braces loose or worn
d) There may be ballast or debris between the switch point and stock rail.
e) Loose, worn or undersized connecting rod and switch rod bolts
f) Worn bolt holes in switch rod fittings

The portion of the plate or pad are designed for the switch point to provide for raising the head of the switch point above the head of the stock rail.

A lip of metal flow may have developed on the gauge side of the stock rail or back of the switch point that should to be removed by grinding.

Switch points can become worn thin because of being located in a curve or because of heavy diverging traffic.

- The top surface of the point can be worn down to a point where the wheel flanges can pass over it.
- Cracks can develop near the tip of the point.
- Chips can break off, either at the end of the point or a short distance behind the point of the switch.

These conditions can result in a wheel flange climbing onto the top of the switch point, just as with a gapping condition.

Switch points must be inspected regularly to see if any of these defects are developing.

- These inspections should include operating the switch so that the fit of each switch point against the stock rail can be observed.

If any of these defects are approaching a dangerous condition, and If the condition cannot be corrected by methods which have been described, it will probably be necessary to replace the switch point.

- With sufficient damage to the switch point, it may become necessary to slow order the switch. (Check with the Track Foreman before any slow order is implemented.)

R. Stock Rails

Usually, when it is necessary to replace a switch point, it is advisable to replace its stock rail as well.

Stock rails are subject to various types of wear.

- The formation of a lip of metal flow on the head of the stock rail is one indication of wear.
- The gauge side lipping, which causes problems, can be readily corrected.

However, lipping is an indication of metal flow that is lowering the running surface of the stock railhead.

If a new switch point is placed against such a worn stock rail, the carefully designed riser feature provided by the switch plates and vertical bending of the switch point will have an incorrect relationship.

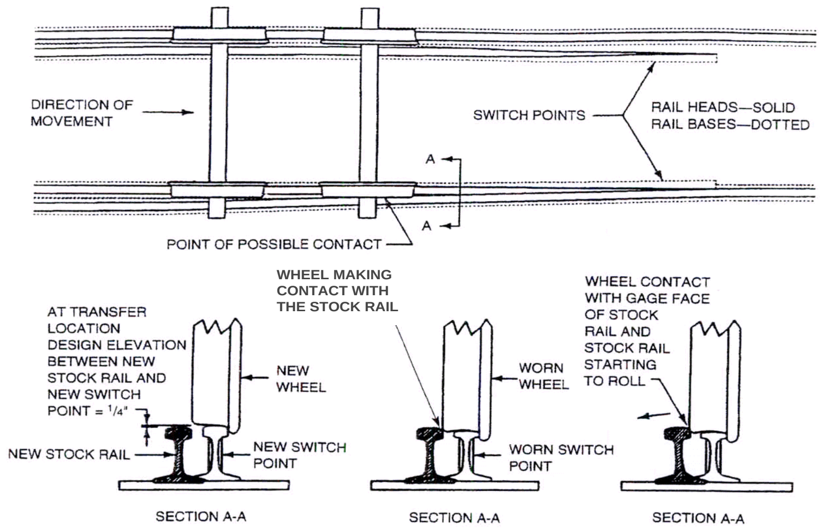
Stock rails sometimes tend to develop mashed heads in the area where the wheel loads are transferred from the switch point to the stock rail on trailing movements.

- This can lead to severe impact on the switch structure.

Switch points are generally more costly than stock rails.

It is good practice to work towards extending switch point life, even if at the expense of some potential stock rail life.

- Many stock rails can be reused as an ordinary rail in a lower class of track.

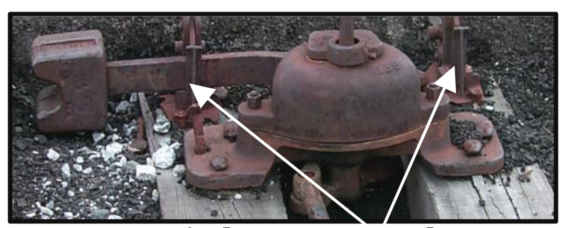


3. Switch Latches and Locks

Power operated switches have a built-in mechanism that locks the operating rod so the closed switch point will not be able to open under moving wheels.

For manually operated switches a means is provided to restrain the lever of the switch stand in its extreme position, thus enabling the operating rod to hold the closed point tightly against the stock rail. `

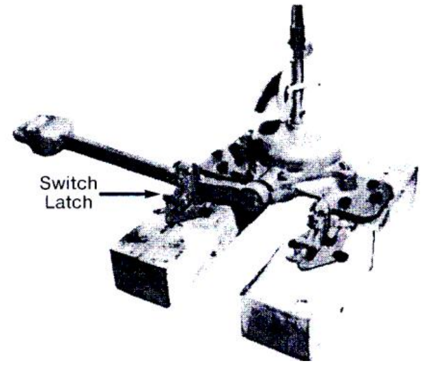
- This is done for both positions of the switch.



Switch Lever Latches

The devices that restrain the lever so the switch point will remains closed, are called **switch latches**. One thing that a switch latch must do is to prevent the lever from becoming free unless the latch is opened. Also, latches must work freely and not jam and should be inspected periodically.

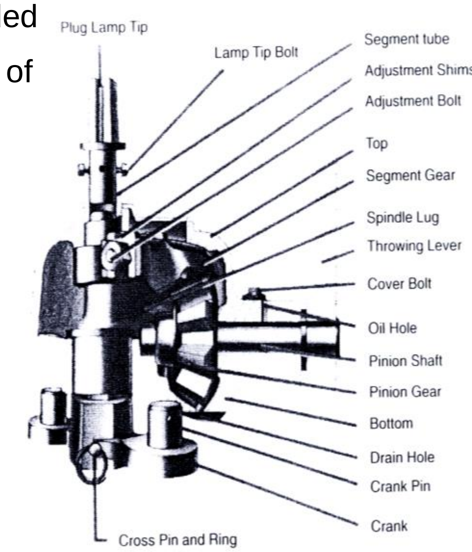
Whenever a switch is located where train movements can be anticipated at a speed where the train may not be able to stop short of the switch if not properly lined, provision must be made for keeping the switch locked.



Here is a picture of a switch stand with latches. Each latch provides for attaching a switch lock, which will prevent tripping of the latch.

Switch can be left in the improper position either erroneously by an employee who used it previously or deliberately by someone intent on malicious mischief.

Latches used in this situation provide for attaching a switch lock. So the switch cannot be operated by anyone without the proper switch key.



This illustration shows the internal components included in the switch stand. There are many different designs of switch stands in use. You will probably only have to work with a few. Become familiar with their parts, so you will be able to make adjustments or repairs when necessary

Any adjustment to the switch points on existing turnouts equipped with switch machine needs to be done with the cooperation of A.T.C personnel.

S. Switch Surface

Much difficulty in throwing a switch can develop because of poor surface of the turnout.

- Under some conditions, most of the load may be carried on a few switch plates
- This can result in one or both of the switch points binding, and being difficult to throw.

Particular attention needs to be given to the switch heel block joints.

- These are hinged joints, and the support they provide is somewhat less effective than with conventional joints

Heel joints need to be watched for a tendency to become low spots in the surface of the track. Loose ties in this area can cause excessive friction on switch plates closer to the point of switch.

There is another hazard caused by loose ties at the heel block joints.

- When a wheel passes over the heel joint and causes further depression, the tip of the switch point can rise up in relation to the stock rail
- Depending on wheel spacing in relation to the length of the switch point, a following wheel can come into contact with an improperly exposed switch point.

T. Switch Surface Information

Surface

Sight the straight rail (line) from a position approximately 30 ft. in front of the switch points, looking towards the frog, with eyes near the level of the top of the rail.

Minor deviation is normal. If deviation is judged to exceed 2”, use 62’ cord to determine the exact deviation. Note measurement on comments page and diagram.

Frogs

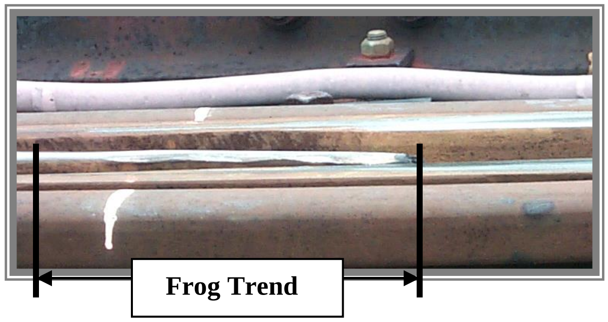
Crossing frogs, in which the tracks cross at 90-degree angles, or other large angles approaching 90 degrees, have open gaps for the opposing flangeways, which wheel must bridge.

Flangeway

These flangeways are about 1-7/8 inches in width.

The impact can be considerable, increasing with the loads on the wheels and the speed of the movement.

The situation is somewhat different for flat angle frogs, including turnout frogs. The open flangeway is on a rather flat diagonal angle.



For a wheel of a given contour, it is possible to develop a frog design for which the wheel load will be transferred gradually from the wing portion to the point portion of the frog on a facing movement.

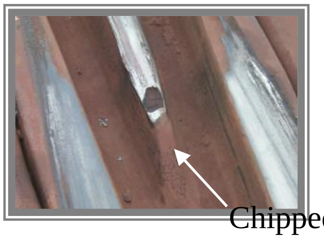
A problem develops since not all wheels have the same contour. Any frog will carry wheels in all stages of wear. As a wheels wears, its shape changes.

In allowing for variations in wheel shapes, it is necessary to design frogs so they are protected against the possibility of wheels striking the tip of the point portion of the frog.

Excessive impact on this relatively narrow part of the frog structure can produce cracking and breakage in a short period of time. There are two ways that this can be avoided.

1. Build the frog, with a slight vertical taper at the point. This results in the top of the point being somewhat lower than the adjacent wing portions combine. On which the outer edges of the wheel treads ride.
2. Keep the point portion level, but raise the wings in the vicinity of the tip of the point. It is from this design that the wing portions of a frog are sometimes referred to as the **risers**.

3. There is a slope of 5/8 inch and going back from the actual point of frog 8 inches that is called the **Frog Trend.**



Chipped Point

The primary purpose of either design is to protect the tip of the frog point. Neither design can provide a perfectly smooth transition of the load across the flangeway for wheels in all stages of wear.

Broken Wing

Some impact will inevitably occur. This can produce batter, cracking, chipping or breakage on either the point portion or the wing where the predominate traffic moves.

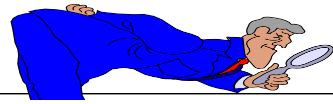
Deterioration of these portions of the running surface of the frog increases the amount of impact that accelerates the failure of the steel surfaces.

- This impact also produces excessive wear on the ties under the frog and the track surface. This, in turn, speeds up the general breakdown.

Welding and grinding can restore the deterioration of the running surfaces, except in extreme cases. If the breakage is not too deep, this work can be done after revenue, without removing the frog from the track.

In more severe cases, it is necessary to replace the frog, but sometimes the frog can be restored to good condition by welding after it is removed from the track.

Severe wear on the point and wing of a frog can introduce the possibility of the flangeway not being deep enough for wheel flanges. Minimum required MARTA specify flangeway depths is 1-1/2". (Use the Frog Gauge to check)



U. Standards for Turnouts and Track Crossings

(a) In turnouts and track crossings, the fastenings shall be intact and maintained so as to keep the components securely in place. Also, each switch, frog, and guardrail shall be kept free of obstructions that may interfere with the passage of wheels.

(b) Classes 3 through 5 track shall be equipped with rail anchoring through and on each side of track crossings and turnouts, to restrain rail movement affecting the position of switch points and frogs.

(For MARTA track, this is applicable only in the Yard tracks, rail clips act as their own anchors on mainline tracks)

(c) Each flangeway at turnouts and track crossings shall be at least 1-1/2 inches wide.

Switches.

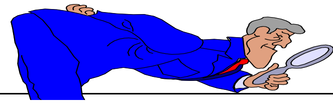
(a) Each stock rail must be securely seated in switch plates, but care shall be used to avoid canting the rail by over tightening the rail braces.

(b) Each switch point shall fit its stock rail properly, with the switch stand in either of its closed positions to allow wheels to pass the switch point. Lateral and vertical movement of a stock rail in the switch plates or of a switch plate on a tie shall not adversely affect the fit of the switch point to the stock rail.

Broken or cracked switch point rails will be subject to the requirements of The MARTA Track Safety Standards

(c) Each switch shall be maintained so that the outer edge of the wheel tread cannot contact the gauge side of the stock rail.

(d) The heel of each switch rail shall be secure and the bolts in each heel shall be kept tight.



(e) Each switch stand and connecting rod shall be securely fastened and operable without excessive lost motion.

(f) Each throw lever shall be maintained so that it cannot be operated with the lock or keeper in place.

(g) Each switch position indicator shall be clearly visible at all times.

(h) Unusually chipped or worn switch points shall be repaired or replaced. Metal flow shall be removed to insure proper closure.

(i) Tongue and Plain Mate switches, which by design exceed Class 1 and excepted track maximum gauge limits, are permitted in Class 1.

Frogs.

(a) The flangeway depth measured from a plane across the wheel-bearing area of a frog on Class 1 track shall not be less than 1-3/8 inches, or less than 1-½ inches on Classes 2 through 5 track.

(b) If a frog point is chipped, broken, or worn more than five-eighths inch down and 6 inches back, operating speed over the frog shall not be more than 10 m.p.h.

(c) If the tread portion of a frog casting is worn down more than three-eighths inch below the original contour, operating speed over that frog shall not be more than 10 m.p.h.

(d) Where frogs are designed as flange bearing, flangeway depth may be less than that shown for Class 1 if operated at Class 1 speeds.

Frog Guard Rails

Minimum safe guard check and maximum safe guard face gauges for the various classes of track are specified in the MARTA Track Safety Standards.

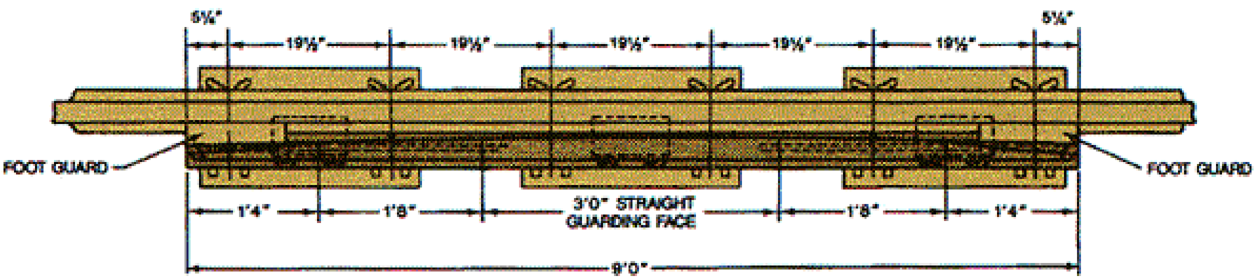
Frog guard rails and guard faces; gauge.

The guard check and guard face gauges in frogs shall be within the limits prescribed in the table found in the MARTA Track Safety Standards.

It is necessary not only to install frog guard rails to the proper, guard check gauge, but also to be certain that both the guard check gauge and the guard face gauge are maintained within the acceptable limits.

- This may require re-spiking or re-lagging of the guardrail, the running-rails or the frog.
- Should this be inadequate to hold proper gauges, switch ties will have to be replaced.

Tee type guardrails, attached to the running rails by bolts and filler blocks or with clamps and wedges require attention to keep the fastenings tightened.



Wear on the guarding face of guardrails is not a serious problem in the majority of installations.

- Where there is a problem, there is usually a combination of curvature and heavy traffic present.

Occasionally, excessive guard face gauge may be involved.

Wear on a guarding face can be a source of concern if it develops to the point that usage limits are threatened or if the mechanical action that produces it loosens the guard rail fasteners.

W. Derails

Their purpose is to prevent the uncontrolled movement of equipment from a sidetrack onto a mainline track. The hazards of a possible collision of such equipment with a train on a mainline track is so great, that it is preferred to delib-erately derail uncontrolled equipment before it blocks the mainline track.

Rail Head, Derail

There are two basic types of derail in general use.

The most common type is placed on the head of one of the rails of the sidetrack.

- This device raises the wheels above the rail so the wheel flanges can be directed diagonally across the railhead.
- As each wheel flange passes beyond the field side of the railhead, it derails.
- This in turn causes the other wheel on the same axle to fall off the other rail to the gauge side.
- In the derailing position the derail block must cover the ball of the rail and lie flat on the top of the rail throughout the underside of the derailing block surface.

This type of derail is normally attached to the rail of the sidetrack, furthermost from the mainline track.

- It must be located so the equipment will not interfere with mainline track clearance, either before or after derailing.
  - a) The purpose of a derail, is to safely derail rolling equipment to stay clear of and away from the track it is intended to protect.
  - b) Derails must be installed:
    - Where there is any possibility of equipment that has been left standing on tracks other than main tracks or sidings being moved by gravity so as to obstruct a main track or siding.

Here at MARTA we use derails behind the MOW shop to keep track equipment from infringing on Yard tracks and where the CSX track connects to the Yard track to keep their trains from entering the Yard.

c) Only approved types of derails are to be installed (examples include):

- Hinge and sliding type derails may be used where the speed of the equipment to be derailed will not exceed 15 mph. A derail wheel crowder must also be installed where any of the following conditions apply:
- Derailing speed could exceed 9 mph;
- The derail is installed on the inside of a curve.

Switch Point Derail

a) Switch point derails are to be used when speed of the equipment to be derailed could exceed 15 mph. Where switch point derails are used, adequate rail anchorage must be provided to prevent rail creep.

- To eliminate the possibility of cars running over hinge and sliding derails without derailing, they must be the proper model, size and hand to fit the running rail.
- The direction of movement of a car to be derailed determines whether a right or left-hand derail is required.
- A right-hand derail is installed on the right-hand rail and derails toward the right; a left-hand derail is installed on the left-hand and derail toward the left.
- The correct size of derail to be used on various rail sections is as follows:

  <u>Size 5</u>: up to 85 LB

  <u>Size 6</u>: 100 LB & *115 LB

  *<u>Size 7</u>: *115 LB and larger*

***On worn 115 LB rail a Size 6 derail should be used.**

- A plywood or steel shim of the correct thickness with holes punched or drilled for all fasteners may be necessary under the derail to ensure the block lies flat on the top of the rail.
- If the rail at the derail location is relayed, the derail should be replaced with one of the correct size for the rail.

b) Operating stands of a rigid type (31B, 36D or 112E) must be used with switch point derails. Rigid stands or Hayes operating stands must be used with sliding type derails.

- Throw of switch point type derails is 5”
- Throw of sliding type derails is 6 ¼”
- The switch stand for, a switch derail will be painted black similar to any other switch stand.

c) ***Hinge and sliding*** derails should be painted yellow.

- All derails not equipped with signals or high operating stands shall have a derail sign mounted on a separate post.
- All derails equipped with high operating stands shall have a derail sign mounted on the mast of the operating stand.
- When derail signs are mounted on the mast of high operating stands, they shall be attached to the mast so that they are parallel to the track when the derail is in the non-derailing position, and at right angles to the track when the derail is in the derailing position.
- Targets and target tips, whether reflective or not, shall not be used in connection with derails.
- Tracks equipped with a derail shall have the switch stand lever painted yellow.

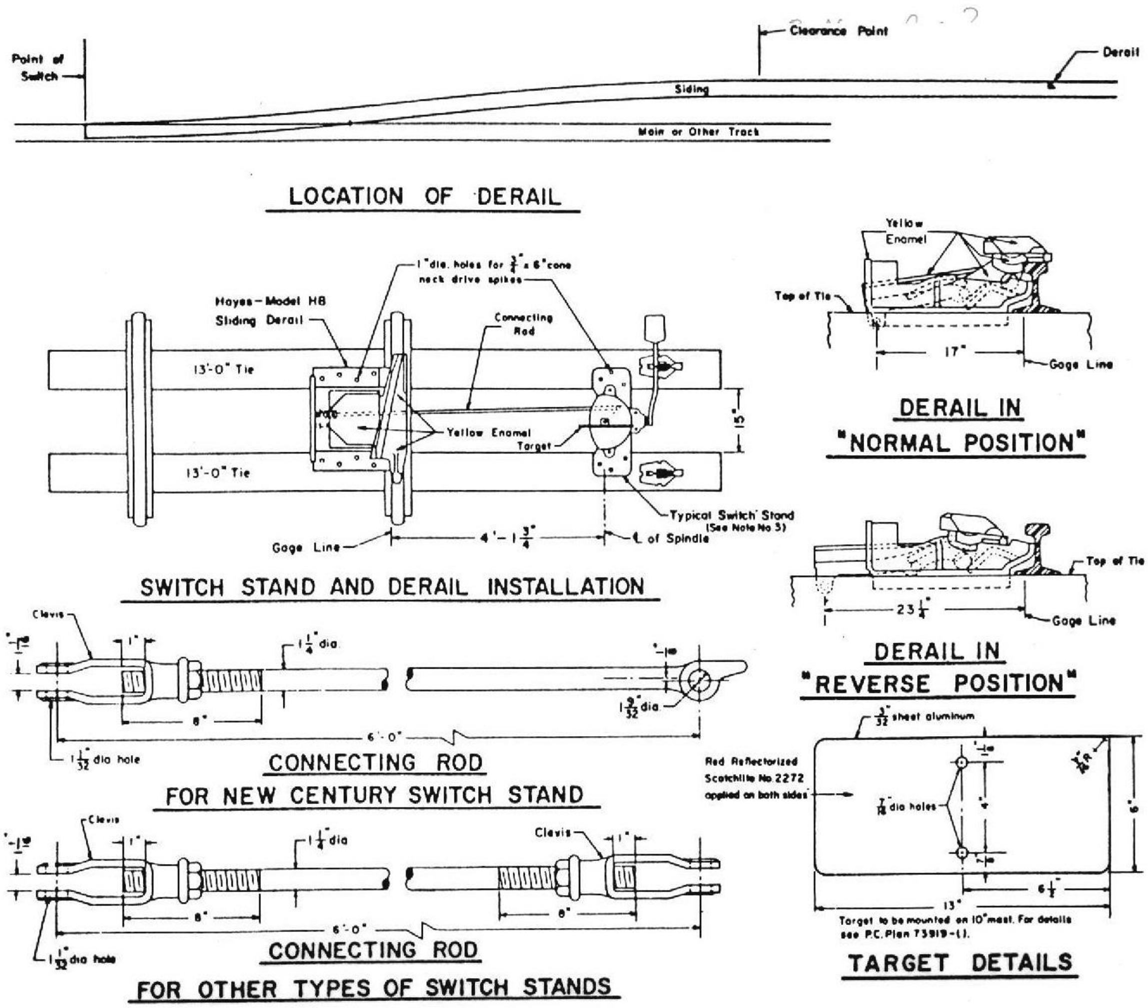
d) Derails must be installed in such a way that equipment will derail away from the track being protected.

- Location for a derail is governed by local conditions such as grade and length of track, but shall never be located less than 20 feet behind the fouling point and installed so as to derail cars away from the track being protected. Sufficient distance should be allowed so that the derailed car cannot continue to move and foul the track being protected.
- When the derail must be located close to the clearance point, a **bent type guard rail** must be installed between the rails, to provide additional assurance that the derailed equipment will not foul the track being protected.
- Derails should not be installed on the inside of curves if it can be avoided. If necessary to install a hinge type or sliding type derail on the inside of a curve, a derail wheel crowder must be installed on the outside rail on the same ties.
- Where there are insulated joints, derails must be placed far enough behind the insulated joints so that equipment derails before fouling the track circuit.

e) Straight guard rails will be required where the derailing point is;

- On a high embankment
- Near structures that could be struck by derailed equipment
- On a sharp curve
- Derails and locks must be kept lubricated and adjusted to maintain ease of movement.

De-rail and Crowder



Occasionally there are instances where this type of derail, is not completely effective. Reasons for this include improper adjustment on the railhead and deteriorated ties which permit the derail to be torn loose. Even without these conditions, a heavy car that has picked up considerable speed prior to contacting the derail will occasionally tear a derail loose.

Typical layout of split switch point derail

Sometimes when the possibility is anticipated such as with a substantial descending grade toward the mainline track connection, a switch- point derail is installed. Usually this is a single switch point and stock rail, located in a similar position to the rail head type of derail. This is located behind the M.O.W. shop where CSX connects to MARTA.

It may be necessary to locate a derail near the clearance point.

- If there is a possibility of derailed equipment fouling the mainline track a deflecting rail may be used.

This is a length of scrap rail spiked to the ties in a diagonal position between the running rails.

- This is intended to guide the wheels that have derailed on the gauge side of the rail away from the main track.

Derails are normally kept set in the derailing position. It is necessary to operate a derail so it will be in a non-derailing position when movements are to be made into or out of the sidetrack.

There are various ways in which derails may be operated. The rail head type is sometimes grasped directly and moved to or from the railhead. This type may be guided by a hinge or sliding mechanism.

Either type of derail may be attached to a switch stand located adjacent to the derail. These de-rails are operated by throwing a switch lever, just as switches are operated. Sometimes, the derail is connected by a system of pipes, cranks and rollers so when the switch is operated, the derail is operated also.

- Where switches are power operated, the derails are also power operated.

Where derails are operated separately from the switch conditions at many locations require the derail be kept locked in the derailing position with a switch lock except when equipment is moving to or from the sidetrack.

- It is essential that such a lock will eliminate the possibility of moving the derail to a non-derailing position.

It is also essential that derails be readily visible to train crews or track personnel working in the vicinity. A lamp, target or a signal sometimes accomplishes this, similar to those used for switches, but displaying the colors prescribed for derails.

Sometimes, the procedure with the rail head type is to paint the derail itself, using a highly visible color prescribed by the individual railroad. It is also necessary to control vegetation and debris so as not obscure the derail.

V. Miscellaneous Maintenance

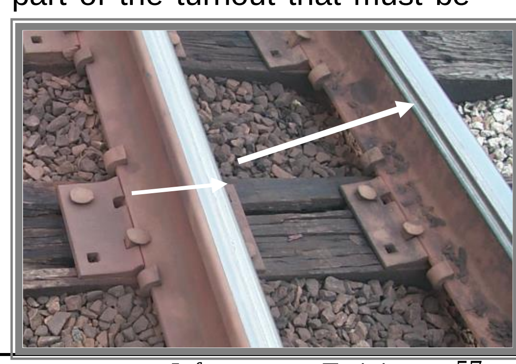
Most turnouts and crossovers have substantial curvature on the diverging route. The nature of these track layouts makes it impractical to provide superelevation on the curved route.

These conditions severely limit the speeds at which equipment can safely be operated over such a route.

- In most installations, only a relatively small amount of excess speed can place considerable stress on the track.

At locations where such tendencies exist, one part of the turnout that must be watched carefully, is the curved lead.

- Under severe usage, a curved lead can develop severe flange wear on the gauge side of the railhead.



- The outward thrust of the wheels can also tend to cause an outward movement of the rail, particularly if the switch ties are nearing the end of their useful life.

Where there are indications of these conditions, the lead area needs to be watched closely for the development of wide gauge.

Most leads have a rail joint somewhere between the heel of the switch and the toe of the frog.

- **This is frequently the most critical location if wide gauge is a problem.**

Turnouts and other special track work have a variety of sizes and types of bolts. In addition to regular track bolts, they usually are:

(b) Connecting rod bolts 2. Stock rail Brace bolts
3. Frog bolts 4. Switch Clip bolts 5. Guard rail bolts
6. Switch Rod bolts 7. Heel block bolts

Each must be properly maintained to perform its function. Periodic tightening and lubrication should be performed.

- If any bolt breakage is taking place, replacements should be installed promptly and efforts made to determine and correct the cause of breakage.
- Also, these installations can potentially present many more ways that train operations can be interrupted than conventional track.

This Lesson has dealt with a wide variety of maintenance and construction functions. You most certainly will not have to make use of all the information that this Lesson contains at once.

However, it is recommended that you do not set this Lesson aside and wait for the day you will have to perform a specific job. Study the types of' switches and turnouts in your areas. Look for signs of defects that this Lesson has discussed. Check resources that are available. Consider how to carry out the various maintenance and construction operations when needed.

W. Diamond Crossings

1. Crossings must be installed and maintained to the plans supplied for each crossing.
2. Sub-grade under crossings must be well drained. Clean crushed rock or slag ballast must be maintained.
   (a) Track gauge and flangeways in the crossing must be maintained in accordance with the plan of the crossing.
   (b) Guard check gauge and guard face gauge shall be maintained as prescribed.
   (c) If the tread portion of a casting is worn down more than 3/8" below the original contour (below level corners where diamond crossing corner pads have been off), operating speed over that crossing may not be more than 10 mph.
3. Crossing must be fully bolted. All bolts must be provided with spring washers or hardened steel flat washers as indicated on the manufacturer's plan, and must be kept tightened to the torque prescribed.
4. Crossings must be spiked or otherwise fastened as prescribed by the railroad.
5. Metal flow on frogs shall be kept ground off to maintain proper gauge and to prevent chipping.
   (a) When necessary, repairs by welding shall be made in accordance with approved methods.
   (b) Reversible crossing inserts must be transferred between corners to equalize wear.

6. Movable point crossings must be adequately lubricated with an approved lubricant.
7. Crossings must be kept free of snow, ice and other obstructions.
8. All ties under crossings must be sound and firmly tamped for 16 inches on either side of both rails on both routes of the crossing.
9. Line, surface and gauge of track approaching crossings must be accurately maintained.
10. Sufficient rail anchors must be applied on all approach tracks to the crossing to prevent rail creep and skewing of the crossing.
11. Inspections of all crossings shall be conducted as follows:
    (a) Every time the crossing is passed it shall be visually inspected for defects.
    (b) Crossings shall be inspected at least monthly on foot measuring gauge and observing overall condition.
    (c) Crossings shall be inspected annually (unless otherwise directed by the Manager of Track & Structures), looking closely at the condition of all components.
12. All unacceptable conditions must be either corrected or reported to the Track Supervisor.

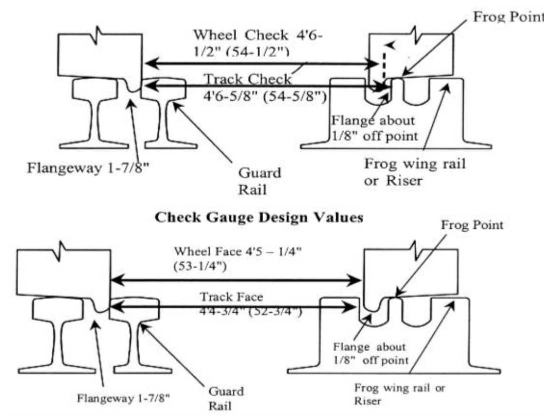
All unsafe conditions which cannot be corrected immediately must also be reported to the Rail Service Control Center and proper action taken to protect traffic on all routes.

13. Crossings must be adequately protected at all times with spare components to ensure continued operation.

Frog and Guard Rail

In setting frog guardrails, there is additional gauging to be done.

- The distance between the gauge line of the frog and the guarding face of the guardrail is to be 4 foot 6-5/8 inches. This is known as the **guard check gauge.**



The distance between the face of the frog wing and the guarding face of the guardrail is known as the **guard face gauge**

Standard guard face gauge is 4 foot, 4-3/4 inches.(52-3/4")

Other Switch Components

Sufficient spikes or lags should be provided to all plates or pads in accordance with MARTA track standards.

Rail anchors should be applied if in the yards. It should be recognized that a major need for anchors usually exist just beyond the limits of the turnout.

- This can prevent the development of track line buckles at locations such as the switch heel blocks and at the heel of' the frog.

Ballast should be kept lower than normal in tie cribs between the switch plates on which the switch points slide.

- This will lessen the possibility of fouling the switch point with ballast or foreign material.
- Ballast must be kept well clear of the connecting and switch rods, in the cribs that the rods occupy.

The head-block ties on which the switch stand or switch machine is placed should be adequately supported with the ballast.

It should be recognized that line supervisors, A.T.C. personnel, E.P.& E. personnel and Track Department personnel frequently work around switch work.

- Often in the dark and adverse weather conditions all the ballast around a switch needs to be properly dressed out.

The switch plates have to be lubricated.

It is essential to check for proper switch point to stock rail fit.

- The switch should be able to throw without any difficulty.

The clearance should be checked between the switch point and the stock rail with each point in the open position.

- This is measured between the gauge side of the stock rail and the backside of the switch point, at a point directly above the #1 switch rod.

For AREMA's standard switches, this should have a gap of 4 ¾ **inches.**

A Standard Of Excellence

Technical Training

Track & Structures

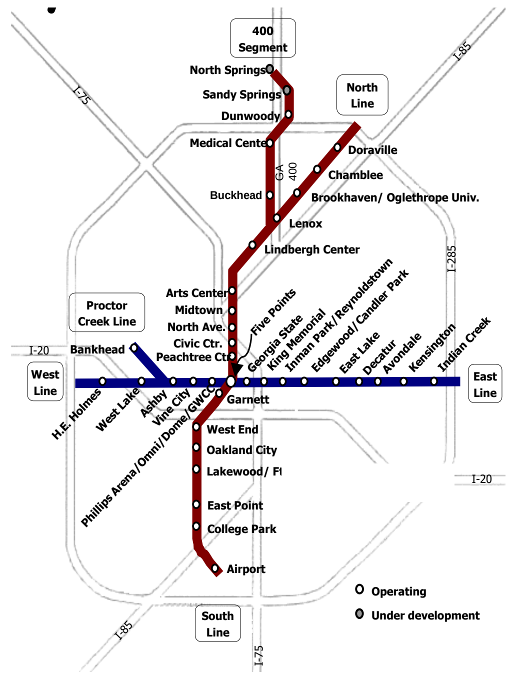
Track Inspection Training

Track Charts

Section 9

READING TRACK CHARTS

The Track Chart Book is set up to always read going away from Five Points Station.



Since Five Points is the center of the MARTA rail system, curves are numbered as they go away from Five Points Station. Also the engineering signs located throughout the system are set up the same way.

The Track Chart Book starts from the front with the East line at Five points Station and goes east to Indian Creek Station.

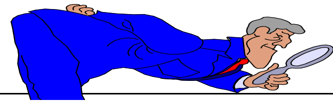
The second section again starts at Five Points Station and continues west to H.E. Holmes Station. (Hightower)

After H.E. Holmes Station comes the Proctor Creek Line, from Ashby Station to Bankhead Station.

Next comes the South line from Five Points Station south to the Airport Station.

Then the North line from Five Points to the North Springs Station.

And after that the North-East line from Canterbury Junction to Doraville Station.



A. Curve Data;

Each block of Curve Data has needed information about the curve.

CURVE DATA

CURVE	ER 1	EL 1
Δ	11°39"-375"	11°39"-375"
R	1400'	1400'
Lc	174.92'	194.92'
Ls	110'	90'
E	2.00"	1.75"

Curve Data Box

In each Curve Data block there is;

Δ = Delta

Delta: The definition: A quantitative change, especially a small or incremental one (this use is general in physics and engineering

R = Radius of Curve

CURVE RADIUS: The measurement of the sharpness of a *Curve* based on its *Radius.*

Lc = Length of Curve

CURVE LENGTH: The distance from the spiral to curve at one end to the curve to spiral at the other.

Ls = Length of Spiral

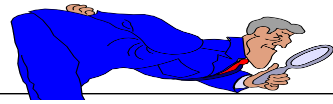
SPIRAL LENGTH: The length or distance from tangent to curve or from curve to tangent.

E = Elevation

ELEVATION: The banking of the track by rising or superimposing the *High R*ail above the *Low Rail* at a *Curve*

Degree of Curve

While the sharpness of a curve can be described by giving its radius, the more common way is to describe it by the **degree of curvature**. You will not have to



determine it in this way, but you can see that the curvature is measured as an angle. Angles are measured in degrees.

- Degrees are subdivided into minutes. There are 60 minutes in one degree.
- Minutes are subdivided into seconds. There are 60 seconds to 1 minute.

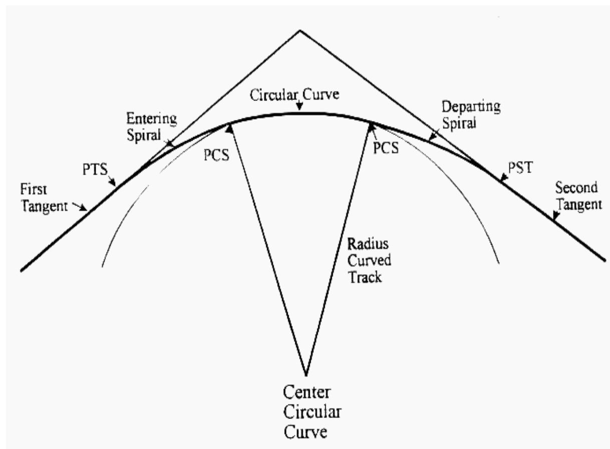
If a curve is described to you as a 2 degree, 30 minute curve (usually written as 2° 30'), you should know that it is a 2-1/2 degree curve.

If a curve is described as a 5° 45' curve, you should know that it is a 5-3/4 degree curve by reducing the fraction 45/60 to 3/4.

- The greater the degree of curvature, the sharper the curve will be.

As shown in the Track Charts, the Delta (△) in curve SR20 is 22º 34' 11.2".

This information may be needed if a Survey of the track is necessary, but will not be need for most work done on the track.



Radius of Curve

All points on a circular curve are the same distance from a certain fixed point, located to the inside of the curve. This distance is known as **the Radius.**

- The greater the radius, the flatter the curve will be.
- The shorter the radius, the sharper the curve will be.

On sharp curves, there are limits on how fast a train can be operated without danger of derailment.

On flatter curves, the speed limits may be determined by the quality of maintenance, rather than curvature.

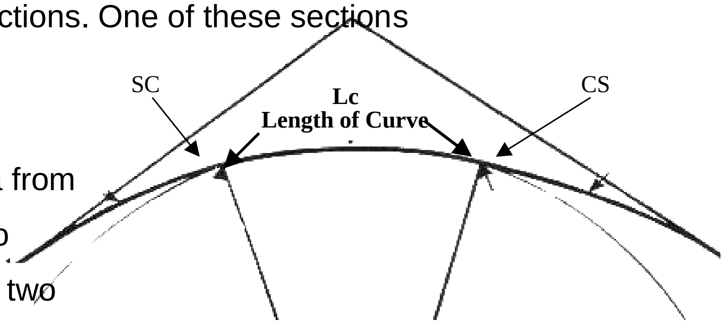
a) Radius of Curve (R) SR20 is 1,600.00 feet.

- This information is important for taking and figuring Stringline readings.
- This information should be noted on the Stringline Data Sheet.

b) It is necessary for the computer program that figures out the alignment and the throws needed for the realignment of the curve to have the radius listed in the String line Data Sheet.

Length of Curve

Each curve is divided into different sections. One of these sections is the Length of Curve.



The **Length of Curve (Lc)** is the area from the spiral to curve point to the curve to spiral point. It's the area between the two spirals.

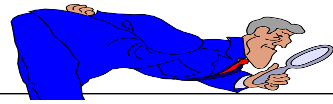
This is where full elevation is reached.

It is here where a constant degree of curve is obtained.

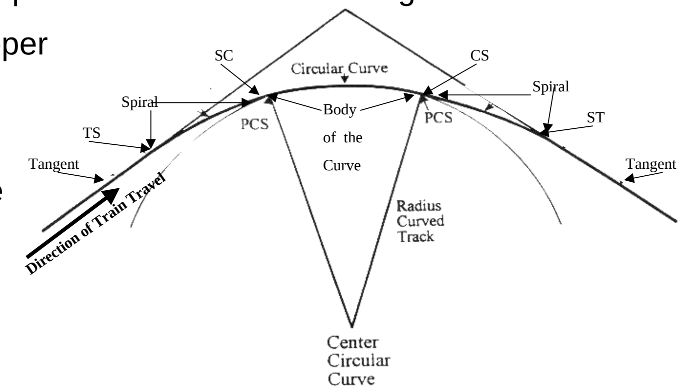
It will also sometimes be called the **Body of the Curve**

- Length of Curve (Lc) shows how long the body of the curve is.
- It is taken from the Spiral to Curve, at the beginning of the curve, to the Curve to Spiral at the end of the curve.

As seen in curve SR20 that is 195.27 feet.



Although this information is not necessary for Stringlining and is not required on the Stringline Data Sheet it is still important information in finding out if the S.C. and the C.S. are in the proper location.



If the curve has moved or the curve was not placed correctly the last time it was surfaced, you will, with this information,
be able to adjust the curve to set it in it's proper location.

Length of Spiral

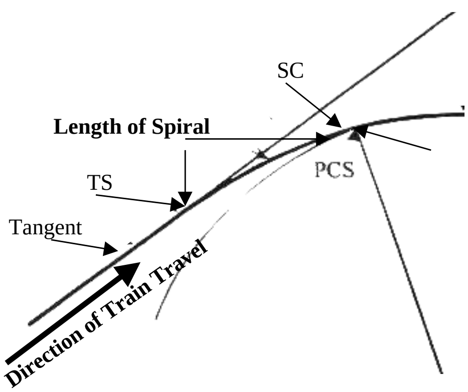
What is done, is to introduce a segment of curve between the tangent and the circular curve which is called a **spiral**.

The spiral consists of gradually increasing curvature from the tangent to the circular curve.

This provides a gradual transition in which the trucks can rotate to the angle required passing through the curve without a lurch.

- Excessive thrust against the track structure is avoided.

The length of the spiral required depends upon the speed at which trains will be permitted to operate and the degree of curve.



Spirals are used with most curves with train operations at moderate to higher speeds. They are used at both the entering and leaving ends of a curve. They are also used to provide transitions between the various curvatures in compound curves.

Length of Spiral (Ls) shows how long it is from the Tangent to Spiral (TS) to the Spiral to Curve (SC) or from the Curve to Spiral (CS) to the Spiral to Tangent (ST).

- This reading is taken from the Tangent to Spiral starting point (TS) to the Spiral to Curve (SC) point. As seen in curve SR20 that is 435.00 feet. This tells how long the spiral in and the spiral out are for this curve.
- The Ls will be the same length at both ends of a Simple Curve.
- The Ls may be different at each end if you're in a Compound Curve.

Elevation

Most curves have the track banked so that the outer rail is raised above the inner rail.

- This banking is properly called **superelevation**, although frequently referred to as **elevation**.

This practice permits a better interaction between the track and the equipment moving over it at substantial speeds. Since curves are so often elevated,

- The outer rail of a curve is commonly referred to as the **high rail**.
- The inner rail is likewise called the **low rail**.

Another advantage of spirals is that the transition from level track to the full elevation required for the curve, can be made in this area.

- This is also an important contribution to smooth riding track.

Elevation of Curve SR20 is 5.25 inches.

- This tells how much higher the High Rail or Line Rail is in the curve than the Low rail.

Starting from Tangent the Elevation increases in small increments until it reaches full elevation in the Body of the Curve.

- This small increase or decrease in elevation is called the Spiral of a Curve.
- Starting at the Tangent and going up in elevation is called the Spiral In.

- Starting at the Curve and going down in elevation is called the Spiral Out.

Full Elevation does not occur until the Full Body of the Curve has been reached.

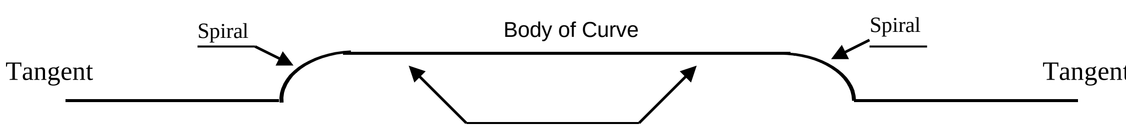
This is important information. It will be needed for Stringlining, Surfacing and Lining track.

❖ In the above information <u>only</u> <u>Radius</u> and track <u>Elevation</u> are needed for Stringlining.

✓ On your Stringline Data Sheet, in the areas provided, fill in the Radius and Elevation information.

B. Alignment Data - Curve Representation,

In this area of the Track Charts, a curve in the track is illustrated by the misalignment of a straight line.



Such as Curve SR 20 or Curve SL 20. This misalignment tells where the track curve begins and ends.

Using the track chart grid the exact location of the beginning and the end of the curve can be determined.

- The area raised above or the area depressed below represent the curve.
- If the area is raised above, this is a Left Hand curve.
- A left-hand curve is a curve that turns to your left if your back is to Five Points Station.
- If the area is below, then this is a Right Hand curve.
- A Right Hand curve is a curve that turns to the right if your back is to Five Points Station.

The method of designating curves as right hand or left hand always relates to the direction of travel going away from Five Points Station.

Information also includes;

- Track Identification (EL, WR, NL,SR, etc.)
- Curve number (EL5, WR14, NL9, SL4, etc)
- Curves are numbered as to their track and position going away from Five Points Station.

  \

C. General Information

Track and Curve Identification,

In the area of general information, different points in the track or curve can be found.

Information includes;

- Track ID. (EL, WR, NL,SR, etc.)
- Curve number (EL5, WR14, NL9, SL4, etc)

Curve Points,

Listed below are the points as found in Curve, SL 20.

TS = Tangent to Spiral (427+21)

<u>TANGENT TO SPIRAL</u> The point on a *Curve*, looking from left to right while standing between the rails and facing the *High Rail*, where the *Tangent* ends and the *Spiral* starts.

SC = Spiral to Curve (432+56)

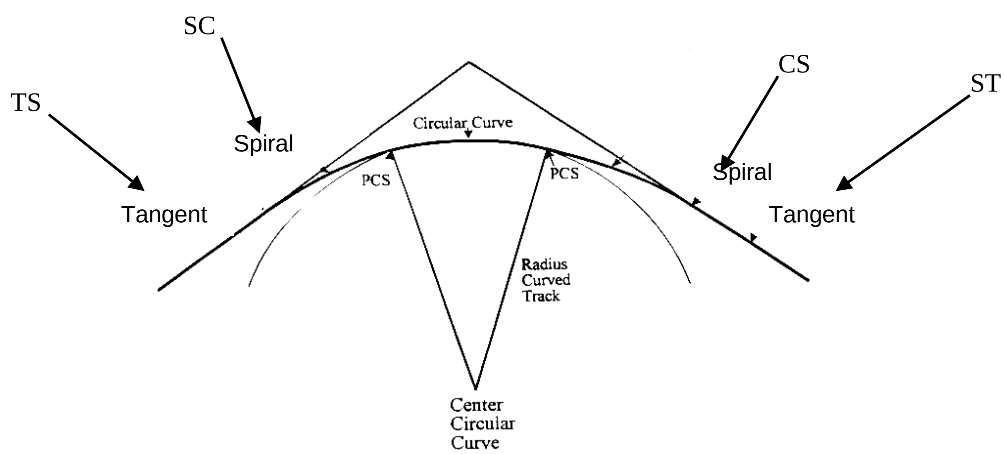
<u>SPIRAL TO CURVE</u>: The point of a *Curve*, looking from left to right while standing between the rails and facing the *High Rail*, where *Spiral Curve* ends and the *Curve Body* starts.

CS = Curve to Spiral (434+98)

<u>CURVE TO SPIRAL</u>: The point on a *Curve*, looking from left to right while standing between the running rails and facing the *High Rail*, where the *Curve body* ends and the *Spiral Curve* starts.

ST = Spiral to Tangent (439+33)

<u>SPIRAL TO TANGENT</u>: The point on a *Curve*, looking from left to right while standing between the rails and facing the *High Rail*, where the *Spiral Curve* ends and the *Tangent* starts.



In Curve SR 20 the TS is 427+31.17 and the TS for Curve SL 20 is 427+21.41.

If we drop the last two digits from both curves then what we have is the curve starting at 427+31 and 427+21 respectively.

Engineering Sign Markers

Engineering Sign Markers are every 300 feet apart outside and 100 feet apart in the tunnels.

Using our wayside Engineering Sign Markers it would be easy for us to go out and find this exact location.

- Do not always count on the engineering signs, they may not be accurate.
- Use the track charts to find a fixed point and measure from that point.

3rd rail insulators are approximately 10 feet apart.

Find an Engineering Sign Marker or a fixed point in the track structure and use the insulators to find your location.

Change in location numbers

Look at station SL 431+00 and SR 431+00 .

The track chart shows there is an equation change at this point.

- 421+00 is the ahead reading for both tracks
- 428+99 for the SL and 429+00 for the SR track are the behind reading.
- This will accrue every so often throughout the track charts to make any corrections in track locations that are needed.
- The CS for this curve can be found at SL 434+99 and SR 434+61.
- The ST for this curve can be found at SL 439+33 and SR 439+96.

These track location numbers do not match track for track. Also a reason for having equations.

- This occurs because of the curvature of the track.
- The outside track in a curve is longer than the inside track of that same curve.

With that in mind as the tracks are going away from Five points Station, each track going out will gain or loose footage with the other track.

- This change in track location will take place throughout the system, changing from curve to curve.

Finding the right starting point.

- It is important that the right information for the curve that's being worked is recorded.

Make sure that you read the correct curve information for the curve being worked.

Curve Location

Finding the right curve is easy in the Track Charts by locating a landmark,

Train Station Interlocking Hi-rail access Abutment

Aerial Structure Bridge Portal Tunnel

Concentric Curves

There are some curves that are identical. Both the curve on the right hand and the curve on the left hand track are the same. Their radius, delta, length of spiral, length of curve and their elevation are identical.

These curves are called **Concentric Curves**.

As shown on Curves NR 7 and NL 7 north of Midtown Station.

Curve	NR 7	NL 7
Δ	0˚ 51' 9.2"	Concentric With NR-7
R	16,000"	
Lc	238.08'	
Ls	N/A	
E	-----	

In these curves

a) delta
b) radius
c) length of curve
d) length of spiral
e) elevation

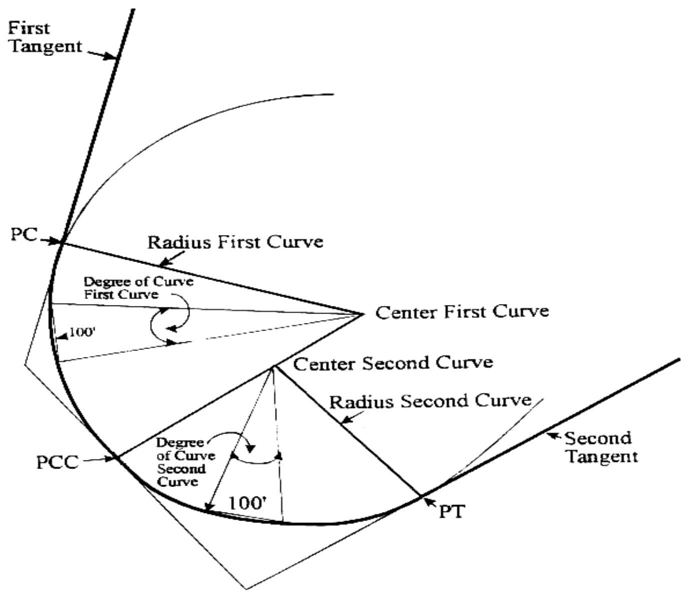
<u>All *are the same from the NL track to the NR track.*</u>

In this case information from one track is the same information needed for the other track.

So the information in the Curve Data Box for the NR track is the same information that is needed for the NL track.

Compound Curve.

At some point in the body of the curve might be a 4° curve, while another point may be a 2° curve.



This is known as a **compound curve**. It is possible to put any number of segments of different curvature into a compound.

Look at the Curve Data for curves NR12 and NL12 we will find another type of curve.

Here we find that the NR12 curve is just like the other curves that we have studied.

It is the NL12 curve that is different.

This type of curve is called a Compound Curve.

A Compound Curve is a curve within a curve.

- <u>Stringline</u>, If you are going to line this curve you must use all the information on that curve and list it on your Data sheet.

- This information is also needed if the track is going to be surfaced.

The information needed includes;

a) All Tangent to Spirals locations
b) All Spiral to Curves locations
c) All Curve to Spirals locations
d) All Spiral to Tangent locations

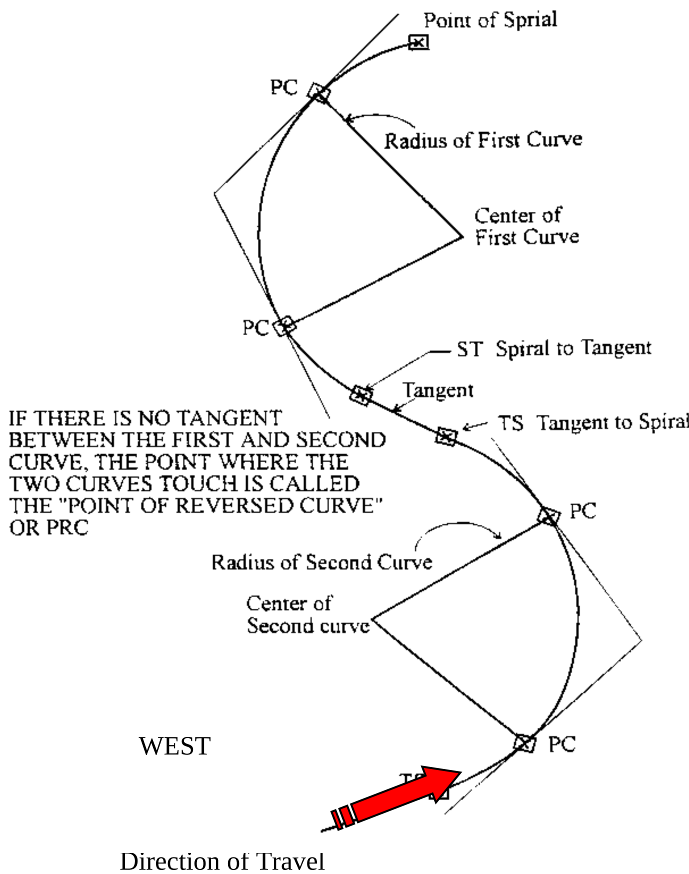
Since a Compound Curve will have one or more of the above curve points, it is imperative that all the information is included.

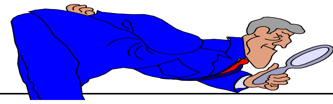
Reverse Curve

For instance, the drawing shows the direction of movement for a certain train. It can also be seen that this train is moving in an easterly direction.

- The first curve this train will pass over is a left-hand curve.
- The second curve is a right-hand curve.

Should a train pass over this track in a westerly direction, the first curve reached would be a right hand curve and the second would be a left-hand curve.





Information for Stringlining includes,

Radius of curve NL12, part 1 and 2

- The radius of curve NL12 part 1 is 3000 feet.
- The radius of curve NL12 part 2 is 2014.75 feet.

Elevation of curve NL12, part 1 and 2

a) The elevation of curve NR12 part 1 is 3.5 inches.
b) The elevation of curve NR12 part 2 is 6.00 inches.
c) According to the F.R.A. manual, for a class 4 track the maximum elevation in a curve is 6 inches.

Since MARTA is a class 4 railroad, no curves will have a greater elevation than 6 inches.

What this shows is that there are two (2) different radius and two (2) different elevations for this same curve.

Each must be taken into account when Stringlining and then when surfacing and lining this curve.

Each must be marked on your Stringline Data Sheet and also marked on the track for future reference.

Also there will be two spirals to curve NL12
(SC1 184+34 & SC2 192+55)

But there will only be one curve to spiral (CS) as the curve spirals out. (201+81)

❖ Remember to mark all SC's and CS's in the curve.

If Stringlining is needed,

a) Stringline and gauge readings are done the same as any other curve.
b) Mark the Stringline Data Sheet with stringline and gauge readings in the areas set aside for these readings.

In General Information you will also find the locations of;

Hi-Rail Accesses	Walkway
Platforms	Retaining walls
Switches	Interlockings
Pocket tracks	Refuge tracks
Storage tracks	Track Centers

All these can be found in the Definition of Railway Terms.

All these points of reference are necessary when finding an exact location of the track.

Many of these may be found in the curve that's going to be worked.

If stringlining, mark the Stringline Data Sheet with the locations of any of these reference points that fall within the curve.

Put its location reference point (such as NR234+20)
The more reference points placed on the stringline data sheet the more accurate your location points will be.

D. Type of Structure

In this area of the track charts you will find the type of structure that the track is resting on.

Different types of Structure,

Since a section of track may have, different structure on which it is built, it is necessary to understand these different types of structures.

On the MARTA system the track could be on one or more of these structural components.

ABUTMENT: A mass of masonry supporting an arch or a beam at the ends of a bridge or an Aerial Structure.

AERIAL STRUCTURE: A long raised structure made of concrete, iron, or steel that allows trains to travel above the surrounding area.

BALLASTED DECK BRIDGE: A bridge supporting a standard ballasted track. This provides for an unbroken track structure, allowing for lining and surfacing through the bridge.

BALLASTED TRACK: Any track constructed with ties supported by *Ballast* in the cribs, on the ends of ties, and under the ties. The amount of rise and fall of a track per 100 feet expressed as a percentage. Also refers to *Ballasted Track* at ground level.

CIRCULAR TUNNEL: A passageway cut through a hill or under the ground and made permanent with masonry or a steel jacket for a track to go through.

CONTINUOS FLOATING SLAB: Slab track that is preformed into long sections and not part of the fixed structure.

CROSSOVER: A pair or group of turnouts, which allow trains or track equipment to cross from one track to another.

DIRECT FIXATION: Method of attaching rails directly to *Bridges, Aerial Structures*, or to concrete without the use of ties.

DOUBLE CELL CUT AND FILL TUNNEL: A passageway that was excavated below the original ground level, cut through a hill or under the ground, double tunnels were made permanent with masonry, for a track to go through and then back filled to cover tunnels.

DOUBLE TRACK TUNNEL: A passageway cut through a hill or under the ground and made permanent with masonry, for two tracks to go through.

HORSESHOE TUNNEL: A passageway cut through a hill or under the ground looking like an inverted horseshoe and made permanent with masonry, for a track to go through.

PRECAST FLOATING SLAB: Slab track that is preformed into small sections and not part of the fixed structure.

RETAINING WALL: A wall constructed to hold in place earth or other fill material where available space does not permit a natural slope.

RESILIENTLY SUPPORTED TRACK: Track that is supported by two-block ties or other material used to deaden track sounds.

SLAB TRACK: Track constructed without ties using a concrete base. Rails are connected to the concrete with Direct Fixation fasteners.

SINGLE TRACK TUNNEL: A passageway cut through a hill or under the ground and made permanent with masonry, for a single track to go through.

If Stringlining,

Record information on Stringline Data Sheet for any transition from one type of track structure to another.

a) Ballasted track to Direct Fixation
b) Switch or Interlocking to Ballasted track.
c) Resiliently supported track (two-block ties)
    - Where adjustments in line and profile cannot be made. Since these ties are set in concrete no adjustments are possible.
d) Tunnel to Direct Fixation
e) Tunnel to Ballasted track

All this information must be recorded to accurately position the track if stringlining or track surfacing and alignment are necessary.

Some portions of the track <u>cannot</u> be moved without great difficulty, such as;

Hi-Rail Access   Interlockings   Switches

It is important that all such structures are noted.

E. Type of Rail

Standard size rail

MARTA uses a standard size rail throughout the system. 115 pound RE rail.

- The RE stands for the American Railway Engineering Association.
- The rail weighs 115 pounds for every three (3) feet of rail.

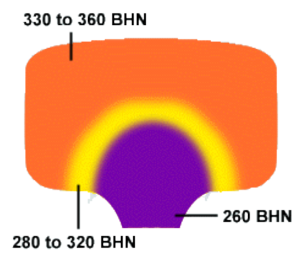
❖ All MARTA running rails are 115 pound AREA rail. What does change is the type of 115 pound rail that is used.

Types of running rail

MARTA uses several different types of this running rail

Standard carbon, non-heat treated used in tangents. All rail is control cooled, but this is usually used to describe standard hardness and metallurgical content rail. On the MARTA system this rail is usually located on tangents and shallow curves. There are several mill making this type of rail, including, Tennessee; Algoma CC 1988; Workington; Wheeling Pittsburgh.

Heat Treated (HT) used in station platforms, turnouts and certain curves. This rail is control cooled rail which has been treated to increase its strength. This rail cannot always be identified by markings, but some can be identified by the following markings; Illinois, US Steel, and CF&I Head Hardened which has a metal tag attached to the rail web.



Having developed a rail-head hardening process wherein the rail-head is hardened to fine pearlitic structure, while increasing the hardness up to 360 BHN. This hardness is attained at the surface of the rail-head and gradually decreases to normal rail hardness at approximately 40 mm 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.

PAINT MARKINGS OF RAIL:

Heat-treated and alloy rails **will have orange painted ends.**

Standard Grade 1 - 39' rails **will have white painted ends.**
The Track Charts will define what type of rail goes into each area of track. This is important when replacing rail becomes necessary. Replace one rail with the same type that was taken out.

F. Profile

Profile

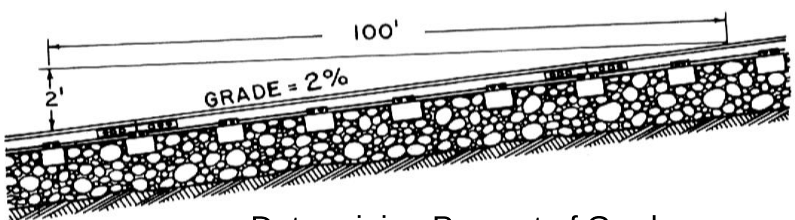
Profile will show the following,

Percent of grade is measured in the rise or fall of a track, in one foot per 100 feet of horizontal measurement along the track.

Track Grade,

- Such as a track having a 2% grade.
- This tells how steep the grade is.
- The larger the number the steeper the grade.

Grade is determined by measuring the drop of the track from one point to the other over a 100 foot section.

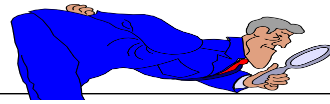


Determining Percent of Grade

If the drop is 2 feet over that 100 foot section of track then that would make it a 2% grade.

If the drop is 5 feet over that 100 foot section of track then that would make it a 5% grade.

Profile also tells the elevation (from sea level) of the track. Along with the beginning and the end of each platforms



G. Traction Power and Trail Control

The Traction Power and Train Control section shows the third (3^{rd}) rail layout and configuration of the system.

Third Rail lay-out

This lay-out shows the following,

Third ($3^{rd)}$ rail anchors locations.

Third (3^{rd}) rail expansion joints locations.

- Where the Third (3^{rd}) Rails break or separates from each other.

Where the third rails are located in the track

- Inside or between the two tracks.
- Outside or on the field side of the track.
- This is determined by putting your back to Five Points Station.

Shows all Third (3^{rd}) Rails located in an interlocking.

Third (3^{rd}) Rail Anchors,

Third (3^{rd}) Rail Anchors can be located by looking for an arrow shaped symbol. ↑

This symbol will be accompanied by a Engineering location. (Such as 427+00)

Each Third (3^{rd}) Rail Anchor is approximately 800 feet apart.

- The Third (3^{rd}) Rail Anchors are another way to find track locations.

Some Third (3^{rd}) Rail Anchors have been moved because of the Concrete Tie Renovation, or by ties breaking and maintenance crews moving the rail anchor to the next good tie.

- Even if this has happened, the Anchor will still be close to the location that's pinpointed in the Track Charts Book.

Third rail anchors can still be used to locate the four curve points.

a) Tangent to Spiral (TS)
b) Spiral to Curve (SC)
c) Curve to Spirals (CS)
d) Spiral to tangent (ST)

Third (3rd) Rail Expansion Joints,

The Third (3rd) Rail Expansion Joints are located through the system.

Third (3rd) Rail Expansion Joints can be located by looking for an open box shaped symbol. ◘

This symbol will be accompanied by a Engineering location. (Such as
SL / SR 428+44)

Each Third (3rd) Rail Expansion Joint is approximately 800 feet apart.

Each Expansion Joint will be approximately 450 feet from the nearest Third (3rd) Rail Anchor.

Using Track Charts to Measure Distances,

At the very bottom of each page of the track Charts will be a set of numbers.

These numbers flow across the page, from right to left, or from left to right, increasing or decreasing in value depending on its location to Five Points Station.

Each line in the grid will equal 100 feet.

Look on Curve SL/SR20.

a) The numbers at the bottom run, from right to left,

440+00 435+00 425+00 420+00 415+00

b) The numbers are increasing by 5+00 each time.

c) 5+00 equals 500 feet.

- Count the grid lines from one number to the other to confirm that each line in the grid equals 100 feet.
- From 440+00 count over 5 grid lines. Those 5 grid lines go to 435+00. Or 500 feet.

Finding Components Using the Grid System.

If a track component can be found in the Track Charts, then using the grid system, the proper track location can be found as well.

On the SL/SR20 curve we can see that the resiliently supported track starts at 440+35 and goes to the portal at 431+25.

The difference of 9+10 or 910 feet.

Look at the 440+35 spot. Now start to count over using the grid lines as a guide.

Since both numbers start in between two (2) grid lines use full grid areas to count. Moving the location to the nearest grid.

- Doing this will get a count of 900.

This will make the exact area only 10 feet off.

That will get close enough to the exact location to be able to find it once that area has been reached.

Using this system it is easy to find the location of any track component.

marta

A Standard Of Excellence

Technical Training

Track & Structures

Track Inspection Training

Track Surface

Section 10

Track Surface

Where matters of track alignment and gauge are involved, the point of reference is always on the inside edge of the railhead, at a point **five-eighths inch below the top of the rail**.

The point of reference concerning track surface is always on **the top of the railhead.**

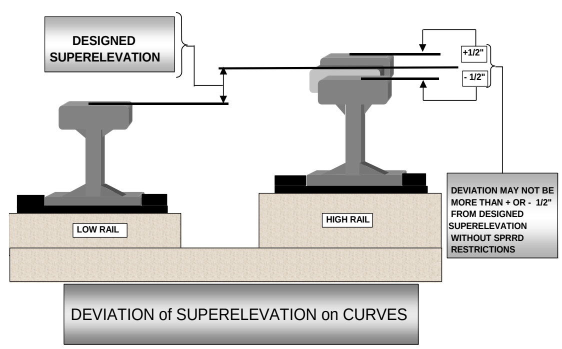
Ideally, the tops of the railheads should always provide a smooth uniform surface, free of humps or dips.

- In addition, the tops of the two rails should have a definite vertical relationship to each other.

The tops of the two rails on tangents should be level with each other.

On curves, where the speed and degree of curvature are great enough to justify it, the outer rail should be elevated somewhat above the inner rail.

The loads, which are placed upon a track structure by modern rolling stock, can be very large.



They can be so great that the underlying structure is not always able to sustain them without a partial breakdown in supporting ability.

One of the large items in any railroad's maintenance budget consists of those funds which are expended in order to maintain adequate track surface.

Millions of dollars are spent each year because the need for good track surface is well recognized by knowledgeable railroaders.

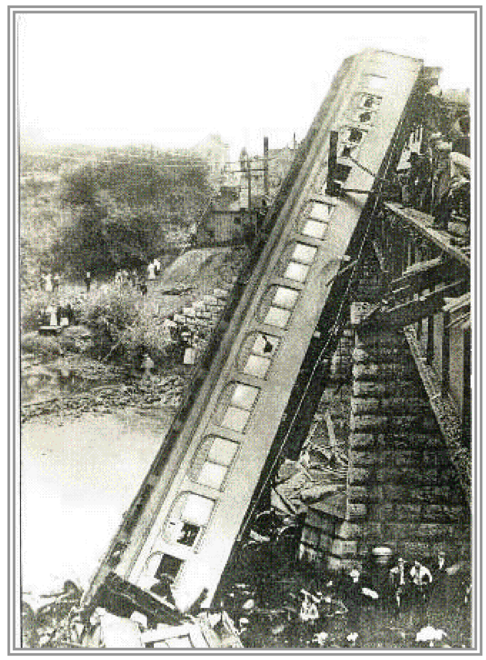
- Its importance can best be understood through a knowledge of the consequences of poor track surface.

A. Effects of Poor Track Surface

The most serious result of poor track surface is the derailment of transit cars or the locomotives.

- This can range from minor derailments, where little or no damage is sustained, to major catastrophes.

Derailments



Defects in track surface can be the sole cause of a derailment, or they can contribute to a combination cause of a derailment.

Derailments are not the only problem created by poor track surface. Harm to passengers, damage to equipment or excessive wear on equipment represent part of the problem.

- Usually, it is very difficult to trace some specific damage or wear to a particular point where track conditions are substandard. Nevertheless, expenses due to such damage are very real.

Another result of poor track surface is accelerated deterioration of the track structure itself.

Surface defects can lead to rail damage, shortened tie life, and fouling of the ballast. It is believed by many that over a long period of time good track costs less to maintain than poor track.

Speed Restrictions

Speed restrictions (slow orders) are a very real part of the cost of poor track surface. This can be in the form of delayed trips, increased crew costs, or both. If the resources needed to correct defects are not available, this alternative must be used. Yet, it should be recognized that it could mean substantial increases in transportation costs.

Track surface irregularities are widespread and can lead to serious consequences if ignored.

Since it is necessary to be able to recognize a track surface problem in order to correct it, detection of defects will be considered first.

Automated Track Geometry Measurement

At least semi-annually all revenue track is measured by an automated geometry measuring system. The parameters measured include gauge, alignment, crosslevel, profile, and twist. This procedure generates an exception report and a graphical representation of all defects, which, exceed designated thresholds. These defects are then manually verified for accuracy and proper track orders are placed as needed.

Profile (surface)

Surface or profile describes the vertical smoothness of the track. Deviations from the desired condition can be observed by sighting the length of the rail with one's eye parallel to the top of the rail. Minor deviation is normal. If the deviation appears abnormal (more than 1 inch) the area should be checked using a 62’ chord and accepted stringline methods.

Flat track should read zero inches. Suspect areas can usually be confirmed by riding a train over the area and noting the ride quality. Refer to MARTA Track Standards (see Exhibit # 15) for appropriate action once the amount of the deviation is determined.

Crosslevel

Crosslevel is the difference in height between the two rails of the track at points directly opposite each other. Design crosslevel on tangent (straight) track and in all turnouts is zero inches and can range up to six (6) inches in curved track. In many curves the outer rail is higher than the inner rail. This difference in height is known as **superelevation**. The superelevation is indicated on metal tags which are affixed to the ties or direct fixation concrete throughout the spiral. The tags cease once full elevation is achieved. Crosslevel is checked with a track level when there is evidence of excessive deviation from normal. Crosslevel defects can be readily identified by riding a train through the area and will be felt as a gentle **rolling** or **swaying motion**. Once the amount of deviation is measured refer to the MARTA Track Standards for appropriate action.

Gauge

Gauge is the distance between the two rails of track at points opposite each other and 5/8 inches below the top of the rail head. Gauge measurements should be made in suspect areas. Unusual rail wear can be an indication of tight gauge. Unusual rail wheel tread pattern on top of the rail can indicate wide gauge. Evidence of fastener movement is another sign of potential gauge deviation. It is very important to understand that there are two types of gauge readings.

The normal gauge reading is a **static**, or unloaded reading. The second case is a **dynamic** reading, or a loaded reading. If there is evidence of fastener movement in the suspect area, the amount of movement must be measured and added to the static reading and the total recorded as the dynamic reading. The dynamic reading is the actual condition that the train wheel encounters. Once the amount of the gauge deviation is determined, refer to the MARTA Track Standards for appropriate action.

Track Safety Standards

The MARTA Track Safety Standards define several different ways in which track surface can be defective. This is done by describing the type of measurement required for each condition.

With each such description, permissible limits are given for each class of track.

- For ready reference the MARTA Track Safety Standards, Class of Track 1-4 for track surface are:

Track Surface

Each owner of the track to which this part applies shall maintain the surface of its track within the limits prescribed.

Any time one of these dimensions exceeds the limit specified for the class of track, speed on the track must be reduced.

- The speed reduction must be sufficient to lower the class of track to one in which all of the track's dimensions are permitted.

If the condition does not meet the requirements of Class 1 track, the track must be removed from service until the condition is corrected.

The only exception to this is that the track may remain in service at Class 1 speeds for a period of not more than 30 days, provided that, in the judgement of the qualified employee making this decision, it is safe to do so.

B. Runoff at End of Raise

The first set of dimensions refers to the difference in elevation between newly raised track and track which has not been raised.

- Such transitions are commonly referred to as runoffs.

There will be a runoff at the beginning of a stretch of track to be raised.

- A temporary runoff will be made each time the track is cleared for the passage of a train and at the end of each day's work.

Runoffs will be needed on connecting tracks that are not to be raised.

If some part of the track structure is not to be raised, runoffs will be needed either side of the un-raised section.

Such locations might include:

- Bridges or aerial structures
- Hi-rail accesses
- Crossovers
- Track under overhead bridges
- Through station platforms.

Finally, a runoff will be needed at the end of the raised portion of track. Runoffs are usually of the same length on each rail.

If a runoff is too short, it will tend to give a vertical bounce to each piece of equipment passing over it. If severe enough, such a bounce can cause broken car springs, breaks in various parts of the trucks or the car body.

A short runoff can also lead to train separations. A sudden change in vertical direction can result in vertical slippage of locked couplers between two cars.

Particularly, in cases where the two couplers were not well matched as to height on level track, such slippage may result in enough vertical movement for the couplers to become free of each other.

- This, of course, results in a separation of the train and an emergency brake application.

Sometimes such incidents only require the train to be re-coupled and started on its way again. In other cases, a severe run-in of the rear portion of the train against the head end might occur and result in a major derailment.

These hazards require that abrupt runoffs be avoided.

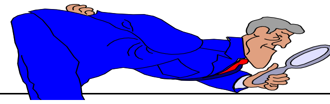
There are two conditions, which determine the length of runoff required.

- One is the maximum speed of trains operated over the track. This is provided for in the table with different dimensions for each class of track.
- The other condition is the height of the track raise. This must be calculated.

For example:

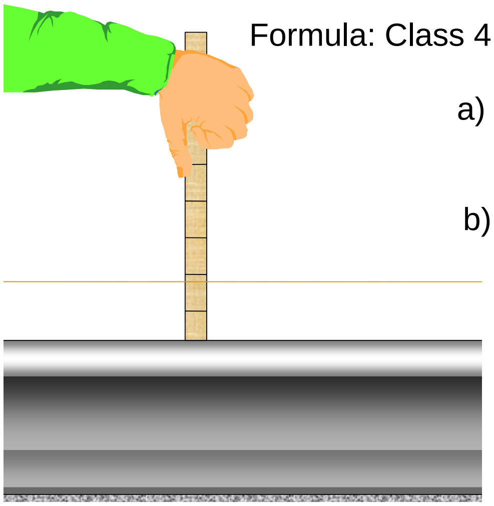
Suppose that a raise of 3 inches is being made for Class 4 track.

- 31 feet of runoff is needed for each 1-1/2 inches of raise.



- Since the raise is 2 times the amount permitted per 31 feet, the length of runoff must be at least 2 times 31 feet, or 62 feet.

Formula: Class 4 = 1-1/2" so 3 ÷ 1-1/2" = 2", 2 x 31 = 62 ft.



a) Length and height of runoffs can be checked with a string, a ruler and a tape-line.

b) Place one end of the string on top of the railhead at a point which has been fully raised, but near the runoff.

c) Lower the other end of the string until the string is just touching the railhead, along the fully raised portion of track.

d) The point at which the railhead and the string first start to separate is the beginning of **the runoff.**

This point should be marked.

e) Holding the string in the same position, measurements should be taken of the distance between the railhead and the string until the point is located where this distance no longer continues to increase.

f) This is the end of the runoff and should also be marked.

g) The distance between the railhead and the string is the height of the raise.

h) The distance between the beginning and end of the runoff can now be measured to find the length of the runoff.

It is now possible to calculate these dimensions in order to find out the class of track to which the runoff conforms.

For example, suppose that by following the procedure just described you have found the length of the runoff to be 53 feet and the height to be 2-1/8 inches. The runoff per 31 feet **(R)** can be found by using the following formula:

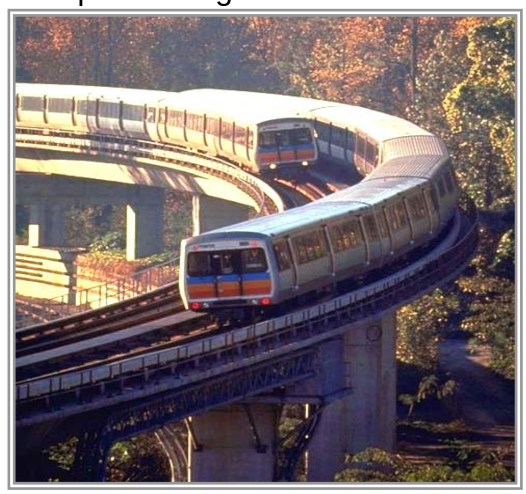
• L - is the total length of runoff

• H - is the height of the raise.

• To simplify calculations, the number 2-1/8" should be converted to a whole fraction which is 17/8

$$R = \frac{31 \times H}{L} \quad \text{or} \quad \frac{31}{53} \times \frac{17}{8} = \frac{527}{424} = 1.24 \text{ inches}$$

A runoff of 1-1/4 inches per 31 feet exceeds the allowance of one inch for Class 5 track, but is within the allowance of 1-1/2 inches for Class 4 track. Therefore, the maximum speeds permissible on this runoff are 60 mph for freight trains and 80 mph for passenger trains



Another situation that must be recognized when making runoffs is the effect of previous runoffs.

Consider a part of the track structure of fixed elevation, such as an bridge or aerial structure. If previous track raises have created runoffs adjacent to the ends of this bridge, no additional track raise can be made within the limits of such runoffs.

- If a new raise of the track is made, the runoffs will have to be made beyond the old runoffs.

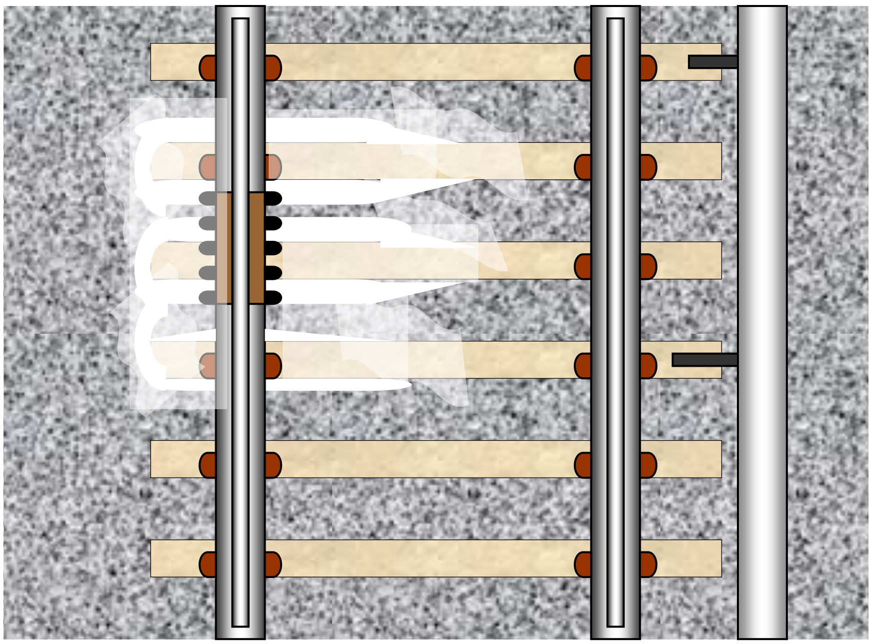
C. Deviation from Uniform Profile

The second standard for track surface, refers to the deviation from a uniform profile on either rail at the mid-ordinate of a 62-foot chord.

It should be recognized that these deviations or irregularities may consist of dips or humps in the rail.

Dips in the track

Dips are most common, as most irregularities in surface are caused by a break-down in underlying support due to the heavy loads imposed on the ballast and roadbed.



The mid-ordinate to the 62-foot chord is measured by placing the string so the center is at the low spot on the railhead *(for dips)* with the ends tightly stretched and held against the top of rail. The distance between the center of the string and the top of rail is then measured.

Humps in the track

For humps, the same procedure is followed, with the center of the string at the high point. The ends of the string should be placed on blocks of uniform height which are placed on top of the rail. The height of the blocks is allowed for in measuring the mid-ordinate.

In cases where the track is on a level grade or on a uniformly ascending or descending grade, these measurements are relatively simple to make.

It has been seen that in horizontal alignment, curves are used to connect tangents. In vertical alignment, curves are also used to connect changes in grade.

There are conditions where the deviation will consist of a hump. Such conditions might develop during cold weather in track subject to frost heaving. A hump might result from a general breakdown of surface on each side of a firmly supported point in the track.

- **A hump might also be caused by the careless jacking of a track.**

Vertical Curves

A vertical curve may be in a sag at the bottom of two opposing grades as in Figure 1. It may also connect the tops of two opposing grades in Figure 2. In other cases, the two grades connected may both be ascending or descending, but of different steepness as in Figure 3.

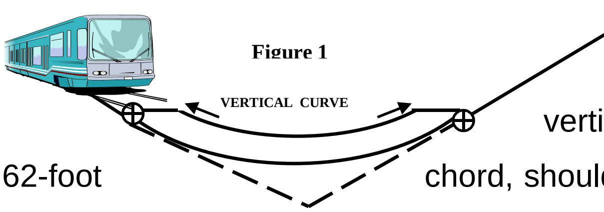


Figure 1

Whenever profile is being checked on vertical curves, the mid-ordinates to the 62-foot chord, should be other than zero. The procedure is to check mid-ordinates at several points within the vertical curve, find the average, then find out how much the mid-ordinate at the point in question varies from the average.

At locations not on vertical curves, the mid-ordinate should be zero.

In such cases, the deviation from uniform profile will be the actual reading of the mid-ordinate. This will apply whether the track is a level, ascending, or descending grade.

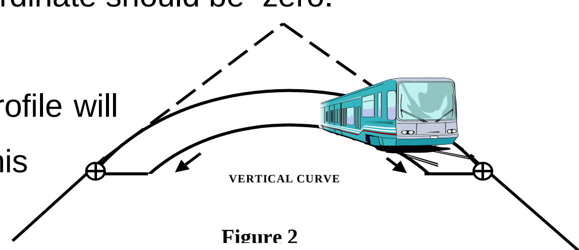


Figure 2

One of these dips or humps may develop on both rails at points approximately opposite each other. Should this happen, moving trains will be affected in much the same way that they are by runoffs.

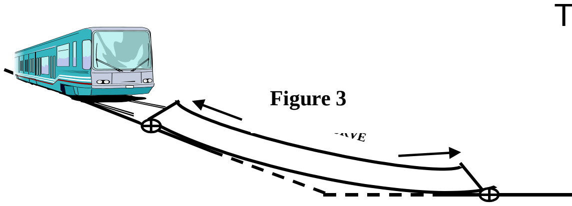


Figure 3

The extent of the irregularity and the speed of trains will determine whether the condition is serious.

If such an irregularity in the track surface appears on one rail only, its influence on trains may be quite different.

- Such a condition is not nearly as likely to cause a parting of locked couplers.

It may start a rocking action in various types of cars. This can be the source of a different type of hazard.

D. Grades

Since the subject of grades has been introduced, it would be well at this point to find out how grades are rated.

A system of measurement is needed because the sternness of the grades on a route can determine how much tonnage a train can haul.

The system which is used to measure grades is based on a length of track 100 foot long. The information needed to determine the grade of a track is the amount of vertical rise in a 100-foot length of track.

- If the track rises two feet in a 100-foot length, it is a two percent grade. (2% grade)
- If it rises 6 inches (0.5 feet), per 100 feet, the grade is 0.5 percent.

E. Cross Level

The remaining standards for track surface are all related to the cross level of the track.

- Cross level is the difference in height between the two rails of a track at points directly opposite each other.

Cross level is usually determined by the use of a cross level or multi-gauge.

To read cross level, the fixed foot is placed on top of the railhead believed to be higher. The adjustable foot is placed on the opposite rail.

The cross level is then adjusted until the bubble is centered with both feet still on the railheads. This is the difference in height of the rails. The scale is normally marked in inches. Fractions can be read to the nearest one-sixteenth inch.

- Sometimes it will be found that the rail assumed to be higher was actually the lower one. In such cases, it will be necessary to reverse the cross level in order to get a reading.

On tangent track, both rails should be the same height. This is zero cross level.

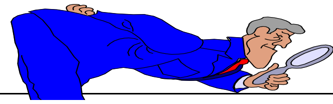
F. Elevation

MARTA standards specify the amount of superelevation required on curves.

- Superelevation, commonly referred to as elevation, is the cross level on curves which have the outer rail raised above the inner rail.

This amount varies with the degree of curvature and the speed permitted on the track.

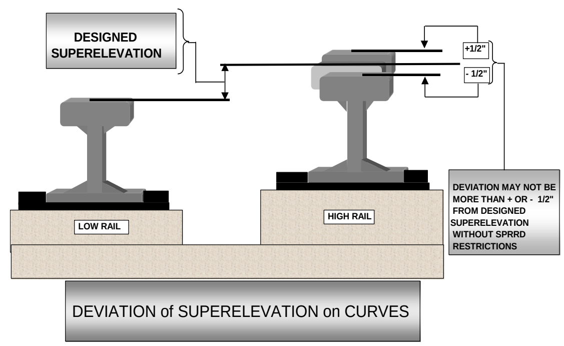
- The MARTA specifications for elevation are given in the table taken from Appendix A of the Track Safety Standards, Class of Track 1-4
- MARTA design standards are set in the **TRACK CHARTS** and can be found for any curve on the system.



A railroad or transit may use this table or it may prefer to use a different one. If a different one is used, it must provide for slower speeds for any combination of degree of curvature and elevation. Higher speeds are not permitted.

Elevation in Curves

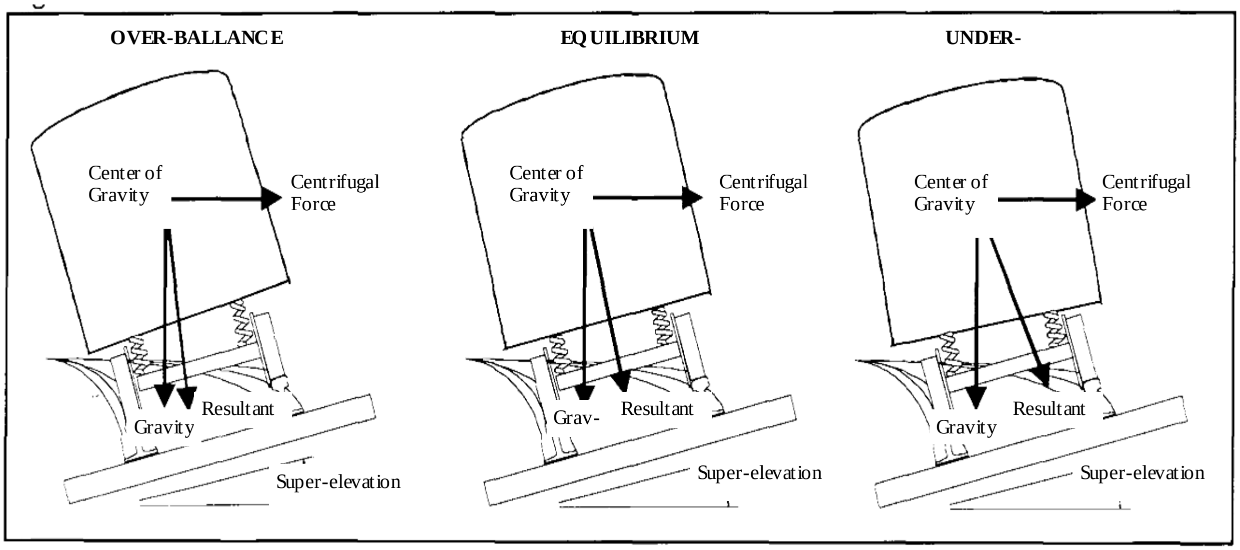
Not all curves have elevation. Refer to the System Track Charts for necessary information on any particular curve or in the section in the back of this book for limited information pertaining to curves.



Trains traveling around a curve are subjected to an outward horizontal centrifugal force that acts conceptually through a car’s center of gravity away from the center of the curve and tends to overturn the cars by directing the train weight toward the outside rail.

To counteract the centrifugal force, the outer rail is raised over the lower rail, or super-elevated. In effect, the combined effect of centrifugal force and weight produces a resultant force that is intentionally moved toward the center of the track. A balanced (equilibrium) condition implies the vertical forces on each rail are equal. This figure illustrates the three types of superelevation.

In practice, transits generally do not operate trains at balanced speed: that is, train speeds are set to move the resultant force toward the outer rail, resulting in an unbalance typically less than three or four inches. Unbalance or cant deficiency is the amount of elevation that would have to be added to the existing elevation to achieve a balanced condition. For Classes 1-4 limit the amount of unbalance to three inches, except that four inches is permitted for authorized and approved equipment types. (Such as our cars)



Safe curving speeds are dependent on the engineering characteristics of the specific equipment involved, as well as the track conditions.

- Equipment factors such as the height of center of gravity, suspension characteristics, reaction to wind and other factors are considered.

G. Effects of Irregular Cross Level

Before proceeding further with the requirements of MARTA Standards, it is necessary to have an understanding of the effects of a change in cross level.

- This can best be done by examining some of the things that happen to equipment on track with cross level changes.

Low rail joints

The examples which will be used will be based upon a transit car. The first example will be based upon a low spot on one rail. This low spot will be rather short in length, possibly in the vicinity of one rail joint. **The track is assumed to be tangent.**

A cross level indicates this spot to be one inch low. A 62-foot string placed on the rail with the low spot also shows it to be one inch low.

- The transit car is placed on this track with one truck directly over the low spot.

Since the track is not level, the truck is leaning. The side bearings between this truck and the car body have minimum clearance. This causes the car body to tilt.

The height of the car is considerably greater than the distance between rails. Because of this, the one inch variation in cross level causes the top of the car to tilt about three inches to one side. (this is a 3 to 1 ratio)

What is Warp and Twist

On the longer rail cars excessive warp or twist in the spirals and in the body of the curves can force the suspension on the diagonally opposite trucks to their extreme limits.

The differential load results in diagonal unloading of the suspension and possible loss of wheel to rail contact
. (the wheels at opposite corners of the rail
car lifting off of the rail)

This problem is exacerbated by the transfer of much of the load to the diagonal side bearings parts of the wheel assemblies.

- When this happens, the trucks are unable to pivot under the rail car, which prevents them from following the curve.
- Under excessive warp or twist, when leaving a curve the lead truck assembly is most likely to derail.

Measuring for Warp

Warp is nothing more than a variation in crosslevel. Take any two cross level readings that are 31 feet apart and find the difference between the two. Choose the largest of the differences and compare it to the table on page 28 of the F.R.A. Track Safety Standards.

Always use the same grade rail for each of the measurements and if necessary mark the readings as either positive or negative in respect to the grade rail.

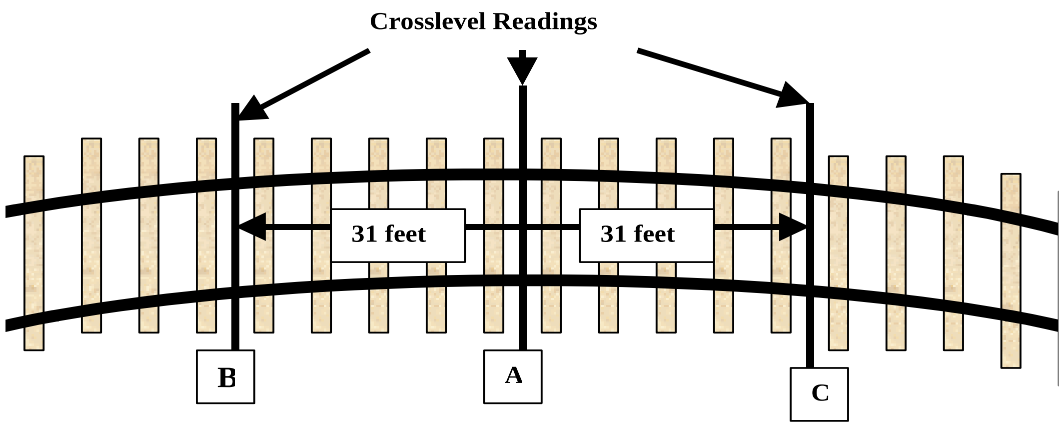
Remember that if the crosslevel must be turned around in order to take this reading then it will be a negative reading.

- This will sometimes occur at dips in the track caused by poor ballast support due to water erosion or pumping rail joints.

Warp Measurements on Tangent Track and in Spirals and Curves

For this measurement, the maximum difference between any two crosslevel measurements that are located within a 62-foot area of each other.

When a crosslevel measurement is taken at a low surface defect a check of crosslevel measurements must be taken on each side of that surface defect for



Crosslevel Reading A = ________
Crosslevel Reading B = ________
Crosslevel Reading C = ________

A - B = ________
A – C = ________

62 feet in order to determine the maximum difference between any two crosslevel measurements within 62 feet of each other.

As always, use the same grade rail for all the measurements and mark the measurements as either positive or negative in relation to the grade rail.

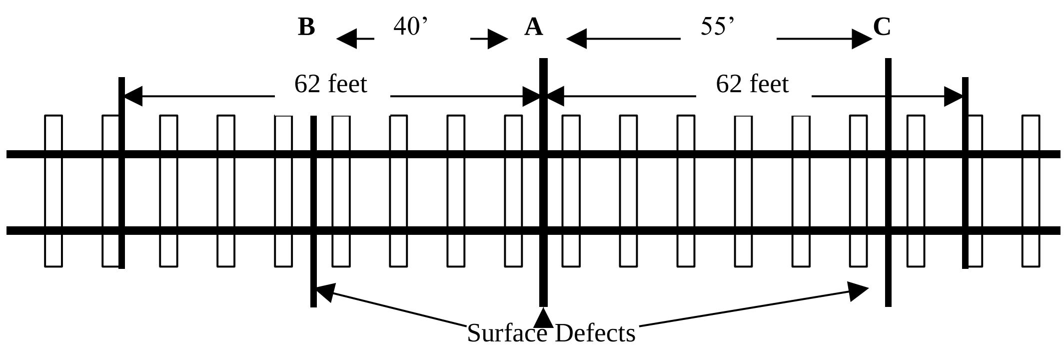
Twist

Twist is not found in the FRA Track Safety Standards Part 213, but is defined as, the difference in crosslevel measurements at the trucks, (wheels) at the two ends of a rail car.

When twist is excessive, frictional curving forces cause the trucks to bind in the rail car thus preventing them from rotating under the rail car and following the spiral and the curve.

Measurements for twist for curves are covered by the definition and limits prescribed for warp on tangents and in curves.

Because the measurement for warp in spirals are too short, additional measurements must be taken for twist in spirals.



Measurement A = __________
Measurement B = __________
Measurement C = __________

A - B = ___________
A - C = ___________

For track twist, take any two deviations in crosslevel measurements that are 62 feet apart and find the difference between them.

- This difference may not be more than 2 inches.

As always, use the same grade rail for all the measurements and mark the measurements as either positive or negative in relation to the grade rail.

More on Twist

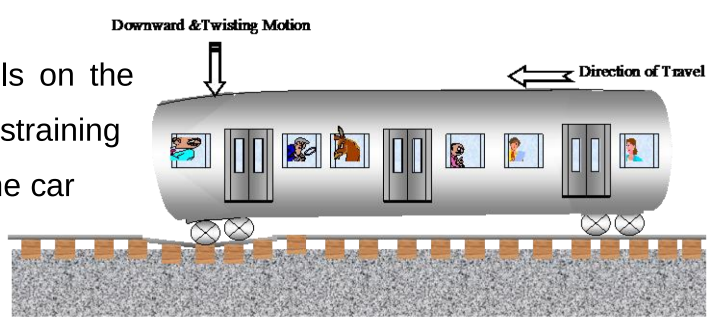
At the same time as the first set of trucks goes down into a dip in the track, the other truck under this car is on level track. That end of the car body is also level.

- This means that the car body is twisted.

The example just described applies to a car that is not moving. Now, consider what happens to the same car when it moves over the same low spot in the track.

As the leading truck moves onto the low spot, the wheels on that rail dip. Since the change in cross level takes place rather abruptly, the tilting of the car body occurs quickly.

- This brings a considerable amount of weight into motion.



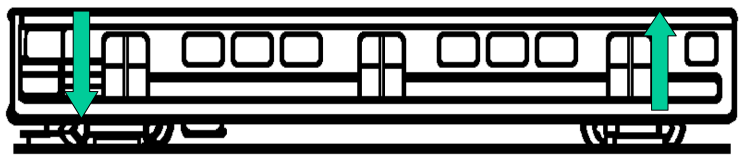
It is now pivoting about the wheels on the rail with the low spot. Some restraining force is needed to stop the roll of the car body.

- This force is in the truck springs.

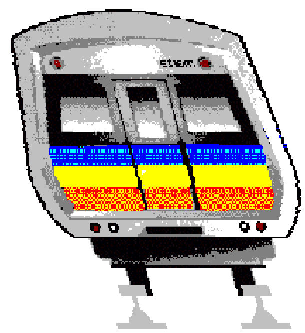
At the point where the maximum tilt or roll occurs, the top of the car body has moved a greater distance than it did when it was on the same low spot, with the car at rest.

- At the same time, the truck springs on the side to which the car rolled are compressed.

There is greater than normal weight on the rails on this side because they are affected by the compressing of the truck springs.



Correspondingly, there is a less than normal weight on the wheels on the opposite rail. All of this happens quite rapidly.



The car is continuing to move. In a fraction of a second, the wheels are coming out of the low spot, back to level track.

- This starts a rolling of the car body in the opposite direction.

This tendency is accelerated by the compressive forces in the car springs. The result is that the car body rolls past the center point in the opposite direction, and reverse forces come into action.

- If this is the only low spot, the car begins to settle down in the vicinity of this track.

While all this has been taking place, the trailing truck has been on level track.

- The car body has undergone a twist in one direction and then quickly twisted in the other direction.

Now the trailing truck of this car approaches the low spot. The entire sequence of events happens again at the other end of the car.

The severity of the car body rolling and of the forces involved depends on several things. They include

1. The dimensions of the surface defect.
2. The speed at which the car is moving.
3. The dimensions of the car.
4. The weight of the loaded car.

The average height of the car and load are known as the **center of gravity.**

Rock and Roll

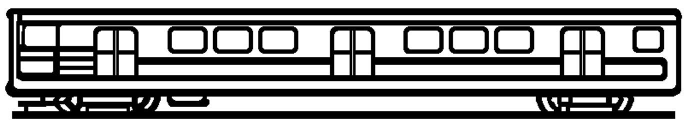
Poor crosslevel can initiate the roll of a rail car. But the most dangerous form of roll is harmonic or resonant roll known as Rock and Roll. Rock and roll occurs when a car with a high center of gravity travailing on soft track at a certain speed moves over a successive series of low spots or low joints with the spacing similar to the distance between the center of the trucks. This rocking magnifies the alternating vertical loads placed on each rail causing wheel unloading and possibly wheel lift. If this occurs on a curve, the wheel may come back down on the flange on the top of the rail head.

Multiple low spots

Suppose, that instead of one low spot in the track structure there are two similar low spots. These low spots are on opposite rails.

- The distance between them happens to be about the same as the distance between trucks of the transit car.

As this car moves over this track, at one point in the sequence of events, opposite ends of the car are trying to roll in opposite directions.



Suppose, also, that this car is relatively stiff and cannot twist very much. It is difficult to say which way the car will go.

It will probably be influenced by the way in which it was tending to rock just before the trucks arrived at these two low spots. The manner in which the car is loaded might have some effect. What could happen is that the car is not fully able to bend to the shape of the track surface.

This can result in a loss of contact between the wheels on one of the low spots and the railhead.

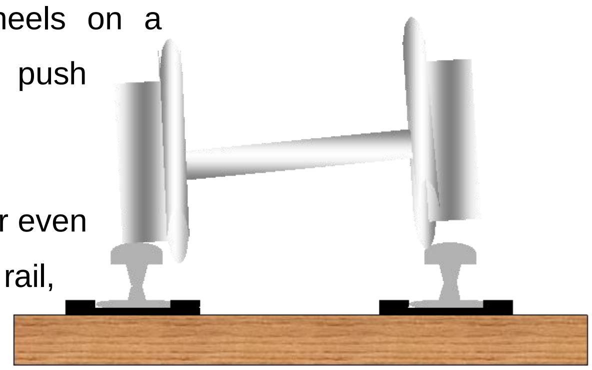
- This would be a momentary situation.

If the track is tangent, wheel contact with the railhead will probably be re-established in a fraction of a second, and this incident will not be noticed.

Loss of wheel contact

But suppose that this occurs on a curve, and that the loss of contact takes place on the outer rail.

- This rail has been guiding the wheels on a curved route by means of a lateral push against the wheel flanges.



This momentary loss of rail-wheel contact, or even a lessening of the vertical wheel load on the rail, can permit a wheel flange to begin climbing onto the railhead.

- Once this happens, the risk of derailment is very high.

This is only one of the ways in which track surface defects can cause a derailment. Assume that there is a series of low joints or low spots on both rails. Assume that the distance between the trucks on the transit car is about the same length of the rails.

- This means that both trucks will be on low spots on the same rail at the same time.

The entire car body will roll to that side. There will be no twisting of the car body.

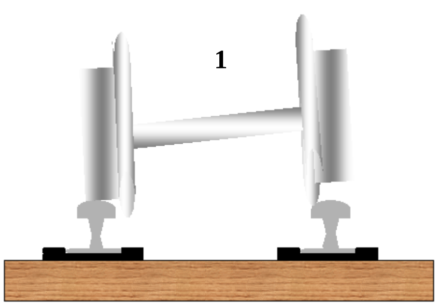
As the car moved beyond these two low joints, it begins to roll in the opposite direction. Even if there are no more low spots, we know that the car body is going to tend to roll past center.

But as the car moves a half rail length, both trucks come to low spots on the opposite rail.

Depending on the design of the car and the speed at which it is moving, the reverse roll from the recovery from the previous situation may occur, just as the car responds to a second set of low spots.

Harmonic rocking

These two forces combine causing a more violent rolling action. This is called **harmonic rocking.**



Given such conditions and a continuing series of low joints, this rocking will continue and probably become more violent.

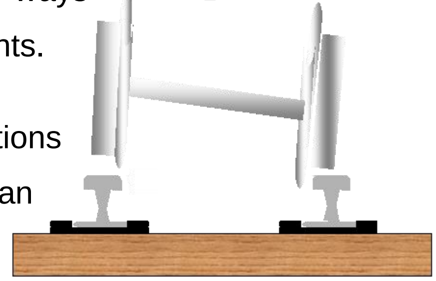
Under such conditions wheel lifts occur in many cases. As in figures 1, 2 and 3.

They illustrate the rocking a transit car can do between low spots in the track surface.

- Again, there is greater danger on curves than on tangents, but a derailment can take place on tangents as well.

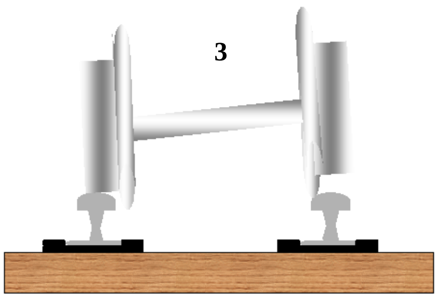
The foregoing descriptions illustrate just two of the ways in which changes in cross level can cause derailments.

2



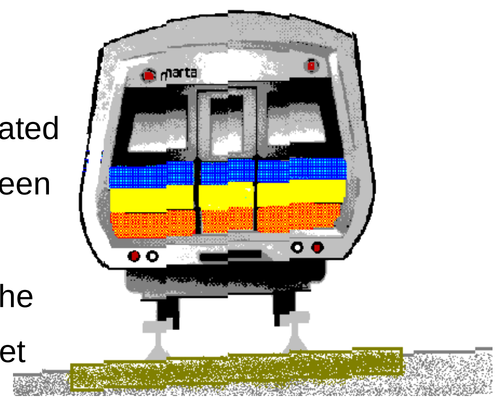
It would be possible to get into more complex situations where derailments can occur, but it is not necessary. It should be evident by now that a great deal of attention must be given to changes in cross level in order to avoid dangerous situations. It is because of this that the MARTA has not one, but several sets of standards to cover cross level defects.

3



H. Runoff of Elevation in Spirals

Attention has already been called to the desirability of the rails being level in relation to each other on tangents.



The need for the outer rail on curves to be elevated above the inner rail in many cases has also been discussed.

- The change from zero elevation to the elevation required for curves has not yet been examined.

It has been shown that abrupt changes in cross level can seriously affect the ability of trains to operate without risk of derailment.

This necessitates a gradual change in cross level at the ends of curves with elevation. In another module, the need for spirals at the ends of curves to meet alignment requirements was discussed.

Spirals are also valuable from the standpoint of track surface. They provide space for a gradual runoff of the elevation which, is needed for the body of the curve.

Transits may designate the maximum rate at which elevation can be runoff.

- This is usually based on increments of 31 feet.

This may provide for different allowances for various speed ranges. For instance, a certain transit or railroad may have a standard which says that for speeds up to 50 mph, elevation may be runoff at a rate up to one half inch per 31 feet.

To apply this, you would have to determine the length of the spiral and the elevation of the body of the curve. You may find that the spiral is of the proper length to runoff the elevation at this rate. For example, if the elevation of the curve is 2-1/2 inches and the length of the spiral is 155 feet, the one half inch per 31 feet will work out properly.

MARTA spirals

At MARTA runoffs for curves are pre-determined by the MARTA engineers when the system was built. Looking in the track charts you will find how long each spiral is for every curve. Divide the **Length of Spiral (Ls)** by the number of ¼ inch increments in elevation.

Let us say that the Length of Spiral is 453 feet, there is 4-1/2 inches of elevation in the curve. There are 4, ¼ inches in every inch.

Then the math is easy. 453 (feet) divided by 18 (There are 18, ¼" in 4-1/2" of elevation) = 25.1 feet of runoff per quarter inch of elevation.

1t is more likely that the length of the spiral will be either more or less than needed to fit the increments of runoff. Such conditions are covered by the following statement from the MARTA Standards Class of Track 1-4:

Elevation of curved track; runoff

(a) If a curve is elevated, the full elevation shall be provided throughout the curve, unless physical conditions do not permit. If elevation runoff occurs in a curve, the actual minimum elevation shall be used in computing the maximum allowable operating speed for that curve.

(b) Elevation runoff shall be at a uniform rate, within the limits of track surface deviation prescribed in §213.63, and it shall extend at least the full length of the spirals. If physical conditions do not permit a spiral long enough to accommodate the minimum length of runoff, part of the runoff may be on tangent track.

Spiral lengths

If the spiral is longer than the minimum needed for a complete runoff, the increments per 31 feet are to be reduced so that the full spiral is used for the elevation runoff.

- Uniform increments are also required.
- Avoid using one half inch increments for part of the spiral and one fourth inch increments per 31 feet for the balance of the spiral.
- Average it out.

If the spiral is not long enough to accommodate the runoff at the specified rate, then the elevation runoff must be started from the point where full curvature begins. The increments are to be reduced through the length of the spiral and extended onto the tangent until the zero point is reached.

Using the example previously given of one half inch per 31-foot increment, with a maximum elevation in the curve of 2-1/2 inches.

- Suppose the length of the spiral was found to be 110 feet.

It has been seen that 155 feet is needed for this elevation runoff. In this case, the point of zero elevation would be on the tangent 45 feet ahead of the beginning of the spiral.

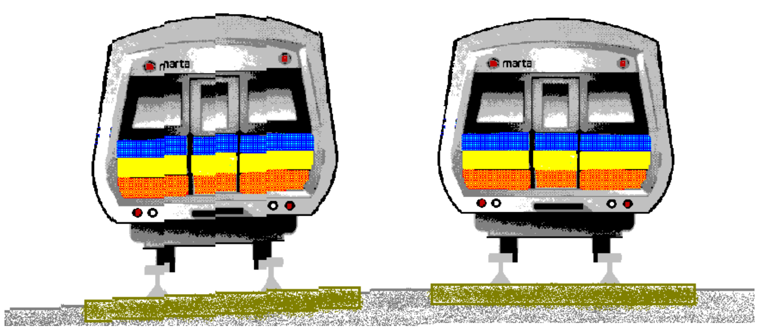
I. Variation in Cross Level on Tangents and Curves

Since it is possible to pick many combinations of two points in any 62-foot length of track, a great many differences in cross level can be read.

- What is needed is to find the maximum difference.

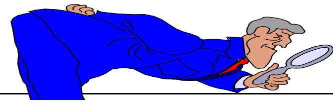
This means finding the maximum cross level reading and the minimum cross level reading on a curve. These readings are subtracted in order to find the difference.

- The distance between two points could conceivably be rather close or it could be any distance up to but not including 62 feet.



In the case of tangents, finding the difference could be somewhat confusing. Suppose that you find a situation within the 62-foot limit where the cross level varies from one half inch (with the north rail low), to 1-5/8 inches (with the north rail low). The difference in cross level is 1-1/8 inches (1-5/8" minus 1/2").

Next, assume that you find a situation which varies from one half inch (with the north rail low), to 1-5/8" (with the south rail low). In this case, the difference in cross level is 2-1/8 inches (1-5/8" plus 1/2").



Example 1:

A 5° curve, with a designated elevation of 2-1/2 inches, has an authorized speed of 40 mph. At one point in this curve the elevation is found to be 1-1/2 inches.

- At another point 20 feet away, the elevation is found to be 3-3/4 inches.

You must determine whether this condition conforms to the MARTA standards. First, you should recognize from the speed limit that this is Class 3 track. The permitted deviation from designated elevation is 1-3/4 inches.

- The first point has a deviation of 1 inch (2-1/2" minus 1-1/2").
- The second point has a deviation of 1-1/4 inches (3-3/4" minus 2-1/2").

These are both within the allowable deviation from designated elevation.

- However, these points are less than 62 feet apart, and the difference in cross level must be considered.
- The difference is 2-1/4 inches (3-3/4" minus 1-1/2").

The maximum permitted for Class 3 track is 1-3/4 inches. Class 3 speeds are not permitted. Actually, this exceeds the 2-inch limit for Class 2 track. Speed must be reduced to Class 1 limits until the condition is corrected.

Example 2:

A certain Class 4 track has a 3° 30' curve with 3 inches of elevation. Cross level readings taken at successive 39-foot intervals are as follows:

3"	2"
2-5/8"	2-1/2"
2-1/8"	3-1/8"
1-3/8"	

All of these readings are within the allowable 1-1/4 inch between two points, less than 62 feet apart. However, the I-3/8 inch reading is 1-5/8 inches less than the designated 3-inch elevation.

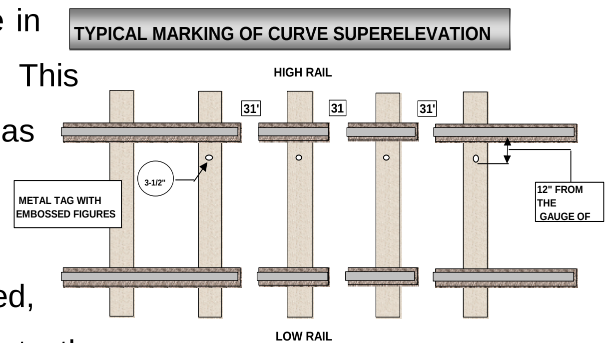
- This exceeds the permitted deviation from designated elevation of 1-1/ 4”

Speed must be reduced to Class 3 limits which permit a deviation of 1-3/4 inches, until the condition is corrected.

J. Marking Spirals and Elevation

It is the practice on some railroads or transits to mark the location of each end of each spiral, at least in the more important tracks. This might be done with permanent markers permanently embedded in the ballast or in the second pour.

In other cases the identification might be in the form of markings on the rail web. This procedure would have to be considered as somewhat temporary.



Another procedure, sometimes employed, is to affix metal tags to the ties closest to these points. These tags can have the advantage of identifying the amount of elevation required at that particular point. This procedure can also be used to indicate the proper elevation at each 31-foot interval within the spiral.

K. Inspecting Track for Surface Defects

Many Track Inspectors have responsibilities for locating track defects within an assigned territory. Usually, the territory assigned is extensive enough to make it impracticable to make the necessary measurements and calculations to positively identify all track surface irregularities without using the engineering signs that are located every 100 to 300 feet wayside.

The experienced Track Inspectors relies on various observations and on knowledge of the territory. When a condition looks questionable, stop and check it with a cross level and, if necessary, with a string.

- Occasionally, a train ride over your territory can help in feeling any rough spots. These points can then be checked later on the ground.

During walking inspections, you have an opportunity to get down and sight the rail, looking for irregularities.

- Suspicious spots can then be measured to establish the severity of the defect.

The Track Foreman may know of conditions within the territory that requires a close check at regular intervals.

For example:

It may be an unstable roadbed condition. A stretch of track with a troublesome rail joint condition may need watching.

- Another area may have a history of frost heaving in cold weather.
- Also keep an eye on a muddy ballast situation and its effects on surface.

Knowing that the surface is more likely to cause problems on curves than tangents, arrange to make a detailed cross level check of one or two curves, each time a walking inspection is made.

- Since the spirals are the most critical points, give these areas the most careful inspection.

Experience is an important factor in a pattern of inspection such as the one just described. This does not mean that it takes many years to acquire such experience. Someone with a desire to learn and a willingness to work at it, can become a competent inspector of surface defects in a reasonably short amount of time.

Close observations paired with frequent measurements will develop reasonable judgment as to the surface irregularities that may need further attention.

Cross Level

Cross level is the difference in height between the two rails directly opposite each other. On tangent track, both rails should be the same height or zero cross level.
In the full body of curves it should correspond with the curve characteristics chart **(Track Charts)** for the elevation required.

In the spirals, it should correspond to the gradual increase or decrease in curvature throughout the spiral. To check cross level, the use of a cross level is required. To do this, set the cross level on the top of the rails, placing the end with the vertical scale on the low rail.

Adjust the cross level until the bubble indicates zero or centered with the bubble scale. Then, read the vertical scale for the amount of superelevation. The scale graduates in 1/16 inch increments.

Since it is possible to pick many combinations of two points in any sixty-two feet, a great many differences in cross level can be read. What must be done is to find the maximum difference.

- That is finding the maximum cross level reading and the minimum cross level reading on a curve.

These readings are subtracted in order to find the difference. The distances between can range up to sixty-two feet.

Technical Training

Track & Structures

Track Inspection Training

Alignment

Section 11

TRACK ALIGNMENT AND GAUGE

The ideal transit to operate and maintain would be constructed on a straight line from one end to the other. It would be the shortest possible route and therefore the fastest and most economical.

From an operating standpoint, there would be no speed restrictions, due to curvature. Train operators would have long sight distances in front of the trains.

Maintenance of track, as well as transit cars, would be simplified in many ways.

Locations where problems with track gauge are likely to occur are closely related to track alignment. This subject will therefore be considered as part of the same lesson.

Before problems of alignment can be dealt with, it is necessary to understand a few basic terms and some concepts, which are followed in established alignment.

The first term is that used to describe a length of straight track. A length of straight track between two curves is known as a **tangent**.

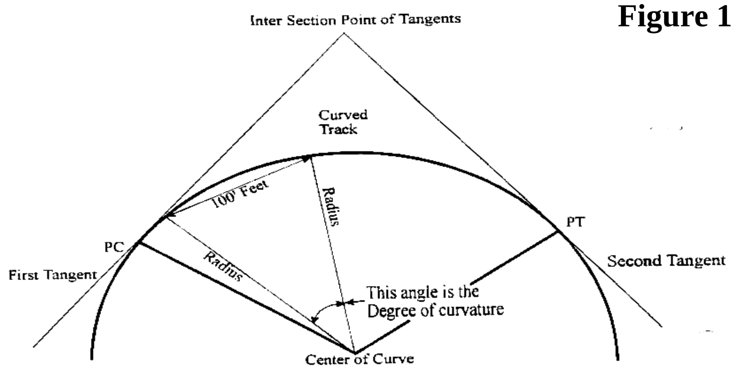
- A tangent may be only a few feet in length, connecting two closely situated curves.
- A tangent might be several miles in length, if such is the distance between one curve and the next.

A. Description of a Curve

Circular Curve

The simplest type of curve used in track alignment is **the circular curve**. Figure 1 illustrates a circular curve with a tangent on either end.

Figure 1



Degree of Curve	Radius - Feet
1°	5780
5°	1146
10°	574
15°	383
20°	288

Rounded to closest foot

Simple Curve
Or
Circular Curve

All points on a circular curve are the same distance from a certain fixed point, located to the inside of the curve. This distance is known as **the Radius.**

- The greater the radius, the flatter the curve will be.
- The shorter the radius, the sharper the curve will be.

On sharp curves, there are limits on how fast a train can be operated without danger of derailment. On flatter curves, the speed limits may be determined by the quality of maintenance, rather than curvature.

While the sharpness of a curve can be described by giving its radius, the more common way is to describe it by the **degree of curvature**.

You will not have to determine it in this way, but you can see that the curvature is measured as an angle. Angles are measured in degrees.

- Degrees are subdivided into minutes.
- There are 60 minutes in one degree.
- There are 60 seconds to one minute.

If a curve is described to you as a 2 degree, 30 minute curve (usually written as 2°30'), you should know that it is a 2-1/2 degree curve.

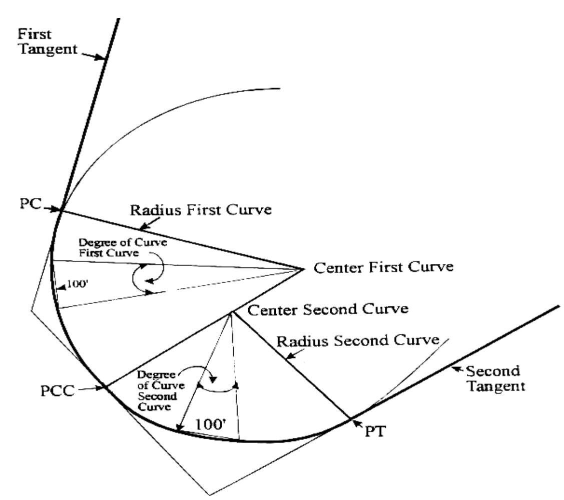
If a curve is described as a 5°45' curve, you should know that it is a 5-3/4 degree curve by reducing the fraction 45/60 to 3/4.

- The greater the degree of curvature, the sharper the curve will be.

Sometimes it is necessary to put two different curves together to fit the track to the terrain. For example, one end of the curve may be a 10° 30" curve, as shown in Figure 2.

Compound Curve

Some curves will have more than one radius. This is known as a **compound curve**. It is like having two curves in one. It is possible to put any number of segments of different curvature into a compound curve.



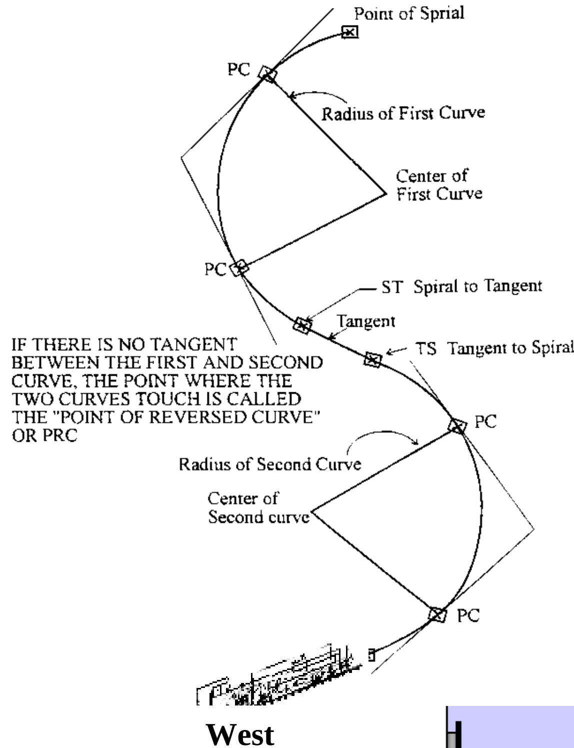
Sometimes it is necessary following a curve, to have a very short length of tangent track which, in turn, is followed by another curve in the opposite direction.

Such combinations are known as **reverse curves**, which are illustrated in Figure 3. An additional method of designating curves, which should be pointed out at this time, is the idea of **right-hand** and **left-hand curves**. Such descriptions always relate to a direction of travel.

Reverse Curve

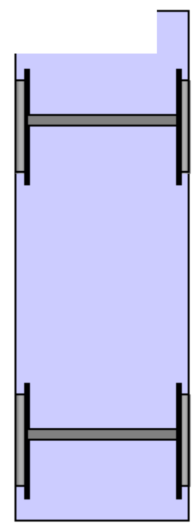
For instance, Figure 3 shows the direction of movement for a certain train. It can also be seen that this train is moving in an easterly direction.

- The first curve this train will pass over is a left hand curve.
- The second curve is a right hand curve.

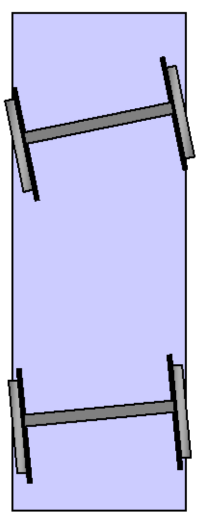


Should a train pass over this track in a westerly direction, the first curve he/she would reach would be a left-hand curve and the second would be a right-hand curve

Next, consider the reactions within a car, and within the track structure, at the point where the car enters a circular curve, as it leaves a tangent.

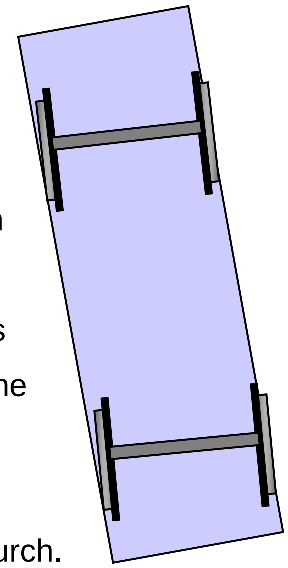


While on the tangent, all wheels were in line with the car body. As the leading car truck reaches the curve, the entire truck must rotate about its center pin, so that the wheels can assume the angle required traveling through the curve.



If the full curvature begins right at the end of the tangent, the rotation of the truck must be accomplished in the very brief time, from the instant the leading axle enters the curve, to the instant when the trailing axle enters the curve.

As the rest of the car moves into the curve, the car body begins to be diverted from the straight line in which it was traveling.



- This causes further rotation between the car and each of the trucks, about the leading and trailing center pins.

There are frictional forces, involved between the center plates on the car body and the center plates on the trucks. There may be additional friction at the side bearings, between the body bolsters and the truck bolsters. The outer rail of the curve has to deflect the wheels and guide them to their new alignment.

As far as the car is concerned, this can result in a considerable lurch.

- This can cause an uncomfortable ride in passenger trains, an increase in the possibility of shifted lading in freight trains, and excessive wear on various equipment parts including the rail.

With regards to the track, the thrust against the outer rail can cause a number of problems.

These include;

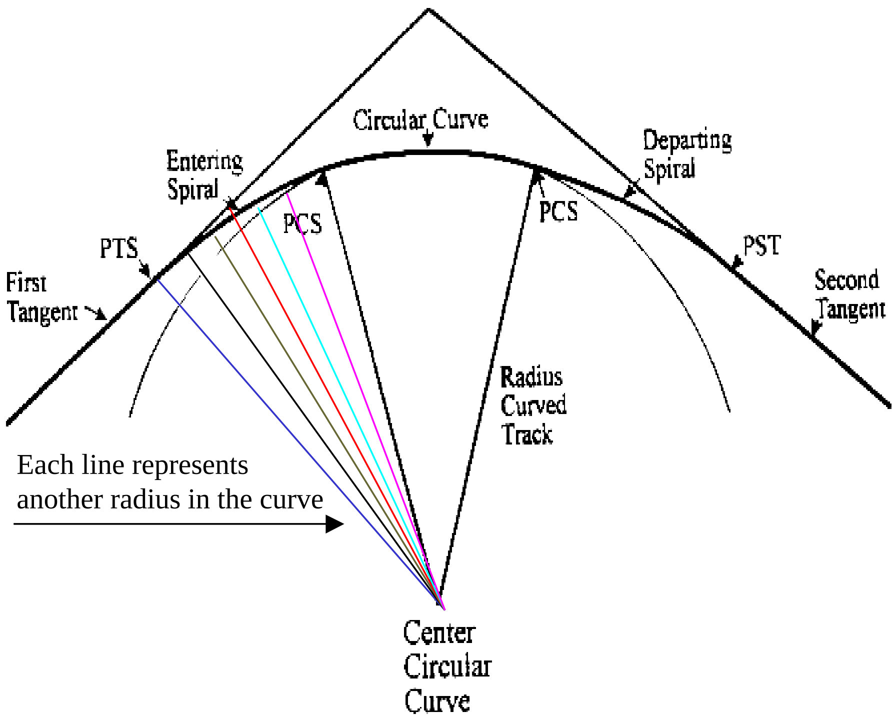
- Excessive wear of the gauge side of the railhead.
- Widening of the gauge.
- Irregular track alignment.
- Deterioration of the ties or Direct Fixation, in this vicinity.
- Ballast problems

Because of these problems, use of circular curves immediately next to a tangent is usually limited to tracks designed for slower speeds where such forces are not very great.

B. Easement Curves

Spirals

What is done is to introduce a segment of curve between the tangent and the circular curve which is called a **spiral**.



The spiral consists of gradually increasing curvature from the tangent to the circular curve.

- This provides a gradual transition in which the trucks can rotate to the angle required passing through the curve without a lurch.
- Excessive thrust against the track structure is avoided.

The length of the spiral required depends upon the speed at which trains will be permitted to operate and the degree of curve.

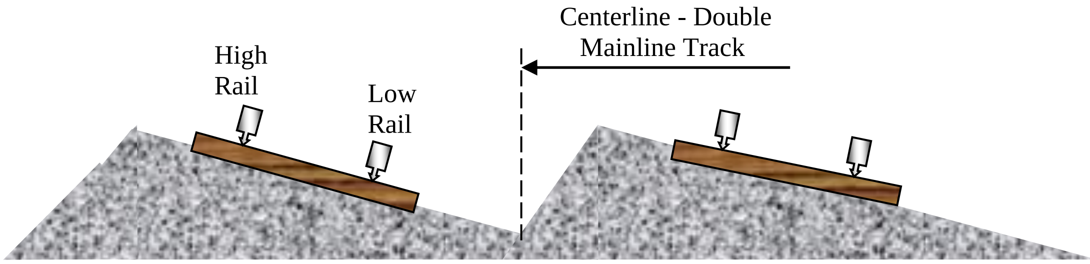
Spirals are used with most curves with train operations at moderate to higher speeds. They are used at both the entering and exiting ends of a curve. They are also used to provide transitions between the various curvatures in compound curves.

Superelevation

Most curves have the track banked so that the outer rail is raised above the inner rail. This banking is properly called **superelevation**, although frequently referred to as **elevation**.

This practice permits a better interaction between the track and the equipment moving over it at substantial speeds. Since curves are so often elevated.

- The outer rail of a curve is commonly referred to as the **high rail.**
- The inner rail is likewise called the **low rail.**



Another advantage of spirals is that the transition from level track to the full elevation required for the curve, can be made in this area.

- This is also an important contribution to smooth riding track.

C. Line Rail and Gauge Rail

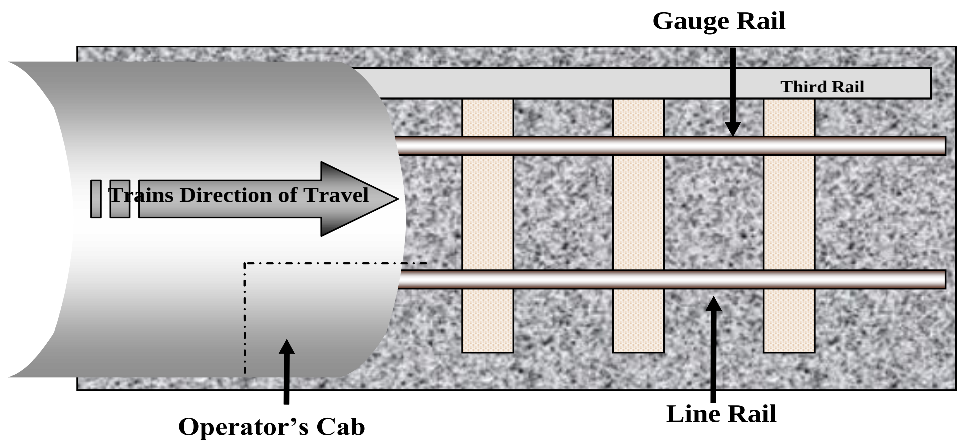
If track always had perfect gauge between the two rails, the alignment of both rails would always be the same. Unfortunately, irregularities in gauge do exist. Wherever these variations in gauge are not uniform, differences in the alignment of the two rails will exist.

Line Rail

For this reason, it is the usual practice to designate one of the rails as the line rail. The idea is that whenever work-involving alignment is done, it should be based upon the same rail or the **Line Rail**.

Gauge Rail

The opposite rail is then considered as the **Gauge Rail**. As long as track is reasonably well maintained, the line rail should have the best alignment.



On Tangent Track, the Line Rail is the Rail Under the Train Operator's Cab

Any work undertaken to correct irregularities in the gauge should therefore be performed on the rail opposite to the line rail, so that when brought to proper gauge, it will have the better alignment.

On a curve, **the outer** *or* **high rail** is always the **line rail.** Therefore, **the inner** *or* **low rail** is the **gauge rail**.

On tangents, the practice varies. Some transits may designate the north, south, east or west rail as the line rail.

- For us at MARTA we use the right hand rail that goes with the normal flow of traffic.

On multiple tracks, it may be the rail closest or furthest from the centerline of the right-of-way. If that is the case, work with the same rail throughout the length of the tangent.

Any measuring or sighting done with regards to alignment should always be done with the same reference line used for gauging. It should be done on the gauge side of the railhead, 5/8-inch below the top of the rail head.

At MARTA we have track that is directional, North, South, East and West. But we also have our tracks identified as Right and Left hand. The Right hand track (with your back to Five Points Station) always goes away from Five Points Station, while the Left hand track always returns to Five Points Station.

The line rail should always be the right hand rail going with the normal flow of traffic, except in a curve where it is the high rail.

D. Defects in Alignment

These are the basic principles used in establishing track alignment. If track always stayed on the proper alignment, these principles would be of little importance.

Such is not the case. Irregularities in alignment do occur, and you need a good working knowledge of these principles to deal with such defects.

We will next consider the ways in which alignment defects develop.

First, consider the way in which stresses within the rails affect track alignment.

- Making a comparison can best do this.

Compare a long steel rail, which may consist of a length of continuous welded rail, or a series of rails connected with joint bars, with another long, slender steel object.

Use your tape-line for making the comparison. If you exert a pulling force on your tape-line**,** your tape measure is capable of resisting a good deal of force before it breaks.

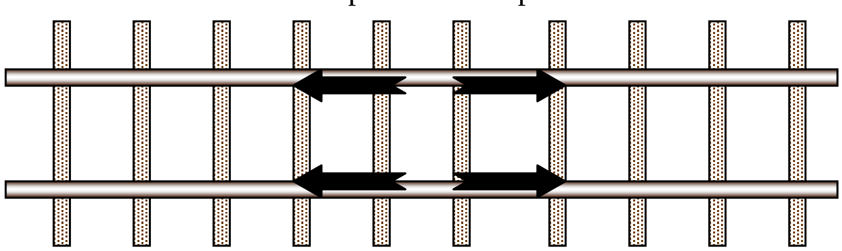
- You also know that if the pulling forces remain in line with each other, the tape will remain in the same line. When this is done, the tape is said to be in tension.

Tensile Forces

The same thing can be expected with rails, which are in tension. The rail will remain in the same alignment, as long as the **tensile forces** are in line with the rail.

If these forces become large enough, track bolts may break. This stress may cause a flaw within the rail to develop into a broken rail.

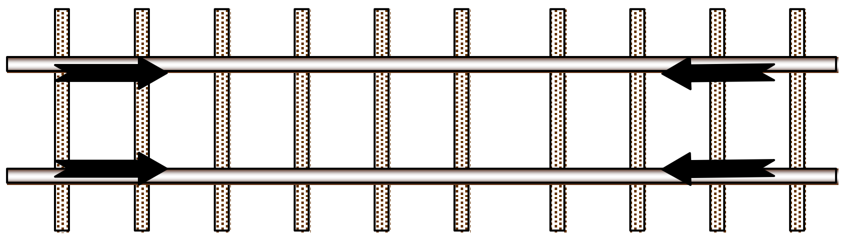
Tensile forces want to pull the rail apart or make it shorter



Also there is a possibility of a flat spot developing within a curve because of tensile forces.

Compressive Forces

Consider what happens when you grasp your tape with both hands and try to push them together. What you are trying to do is to put the steel into **compression**.



Compression forces want to stretch the rail and make it longer

As soon as you apply a small amount of compressive force, the tape begins to buckle.

- This is not caused by any lack of strength within the rail or track structure. All sorts of distortions in its alignment may occur; it is caused by the shape of the tape.

Long, slender objects have relatively low resistance to buckling, when compressive forces are applied. The comparison between the steel tape and the steel rail is exaggerated; but the principle is the same.

If large compressive forces are applied to a rail, it will tend to buckle. When the rails are spiked or clipped to the ties or pads, the resulting track reacts to compressive forces in the rail as a unit.

- This structure is not nearly as slender as a single rail, which increases its stability.

Embedding the ties in ballast will increases resistance to buckling further. Still, in relation to their length, transit tracks are relatively slender. Large compressive forces within the rails are capable of producing lateral displacement of the track, or poor line.

E. Effect of Temperature

You should understand how compressive and tensile forces develop within a track.

Causes of Temperature Change

One cause is temperature change.

- Steel tends to contract or shrink as its temperature is lowered. If it is restrained, so that it cannot contract, a tensile force is built up within the steel.
- As the temperature of the steel is increased, it will tend to expand. If some restraint does not permit it to expand, a compressive force develops within the steel.

In track with bolted rail, these forces are partially relieved with the expansion and contraction of the rails permitted by the rail end gaps at the joints.

The forces are not fully relieved due to frictional resistances at locations such as the joint bars, tie seats and clips.

Median Rail Laying Temperature

The exception to this, is some median temperature where the stresses within the rail are about to pass the point between tension and compression.

In track with continuous welded rail, expansion and contraction cannot occur. This results in much larger tensile stresses in cold weather and compressive stresses in hot weather.

Changes in temperature are not the only things that cause tension or compression within a track.

- Rail tends to move under traffic.
- On tracks where most of the traffic is in one direction, it usually tends to move in the direction in which trains move.
- The general trend on grades is for the rail to move toward the bottom of the grade.

These are generalities and there are many exceptions.

The Pandrol fastening system does not allow ether vertical or longitudinal rail movement within the track structure. They take the place of rail spikes and rail anchors.

Rail anchors are applied to prevent such longitudinal movement. Properly applied rail anchors, in sufficient quantity, with ties, while embedded in ballast, can do an excellent job of controlling longitudinal movement.
It must be recognized that only a small amount of movement can cause large forces to be built up within the rail.

Consider an example of the size of the forces involved.

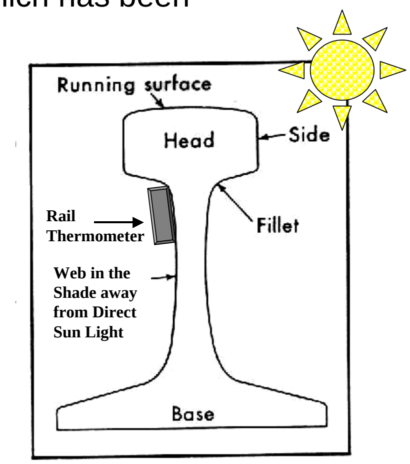
- Assume that a length of welded rail is laid out on rollers to minimize friction.

Suppose that the length of this rail is about 1,400-feet, which is a common length used by many transits and railroads for continuous welded rail.

The length of the rail is measured accurately on a winter day when the temperature of the rail is 0 degrees Fahrenheit.

The rail is left undisturbed until a warm summer day when the rail temperature is found to be 120 degrees.

- This is not an unusual temperature for a rail, which has been exposed to direct sunlight for several hours.



The length of the rail is again measured and found **to be more than one foot longer** than it was at 0 degrees. This expansion and contraction of the rail causes great stress on the track structure.

F. Tremendous Rail Pressures

Next, suppose the same rail is laid securely in track and well anchored at a time when the temperature is 0 degrees. As the temperature increases the rail is unable to expand. Since it can't expand, compressive forces begin to develop within the rail.
The warmer it gets, the greater the compressive stress becomes.

By the time the rail attains a temperature of 120 degrees, the compressive force within a rail of one of the heavier weights in common use can exceed 300,000-pounds.

- If each rail attains a compressive force this great, the total compressive force in the track, at any one area, could be over 600,000-pounds.

A track subjected to such large compressive forces becomes extremely unstable. The alignment can become distorted due to sun kinks or even sustain severe buckling.

- Welded rail should not be laid at cold temperatures without being heated or readjusted, as soon as it is warm enough.

Preferred Rail Laying Temperature (PRLT) for MARTA is 80º F

Similar conditions can develop through a combination of movement under traffic and temperature changes.

If not properly anchored, bolted rail may move in one direction until it comes against a part of the track structure that is firmly secured.

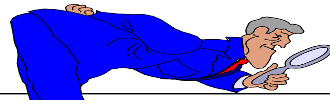
This might be a turnout, a crossing, aerial structure or any location where the rails are well anchored in solidified ballast.

- If this process continues until there are no rail end gaps over a considerable distance during cold weather, high compressive stresses will develop in hot weather.

Compression within the track structure is only one of the reasons for the development of defects in track alignment. Some line irregularities are caused by compressive forces within moving trains.

Because of the possibility of buckled track, special attention must be given to the following track areas.

1. In a curve.
2. In a dip.
3. At the bottom of a grade.
4. On approaches to bridges and aerial structures.
5. Recently disturbed track.
6. Work during the past winter and the rail was not adjusted or ballast not restored.
7. Where a curve has shifted inward and has not yet been relined or adjusted.
8. Where rail has been replaced due to defects or service failures and not properly adjusted.
9. Where rail is running.
10. Prior to a hi-rail access or a turnout.



Look for indications that track is about to buckle, look for the following

1. New line deviations.
2. Wavy or snaky rail alignment.
3. Rail rotating or lifting out of the pads.
4. Intermittent loose pads or clips.
5. Rail running.
6. Clips moving.
7. Insufficient rail clips.
8. Insufficient ballast in cribs and shoulders.
9. Gaps in ballast at the ends of ties, especially on the low side of a curve.
10. Previously buckled track that was not properly repaired.
11. Ballast disturbed around a tie.

G. Effects of lateral Forces

There are several things that could happen if these lateral forces are large enough.

1. One or more cars could derail as a result of wheels climbing over the head of a rail.
2. When wheel flanges against a rail apply the lateral forces, the rail might overturn.
3. In other cases, the rail might remain upright, but the rail could slide outward resulting in wide gauge.
4. Another possibility is that the track structure would remain intact, but shift laterally.
   - This could leave a small irregularity in the track alignment, or a major distortion.
   - This also could be extremely dangerous in the case of bridges and aerial structures, moving them laterally on their support peer.

There are other ways in which train-handling incidents can leave the track structure with line or gauge defects.

Such incidents can happen through such varied activities as the use of pusher engines or dynamic brake application.

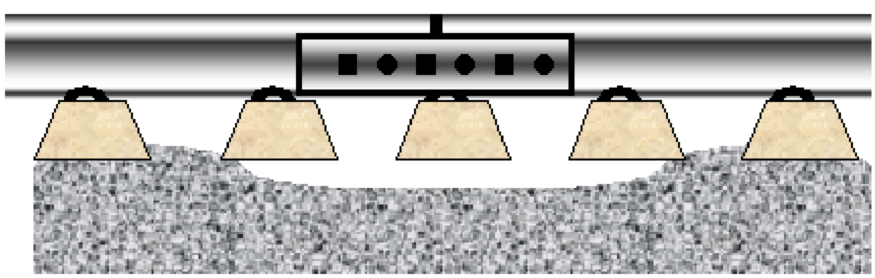
H. Other Causes of Line Defects

Line defects can also be caused by inability of the ballast or roadbed to support the vertical loads placed on it.

Line Defects Because of Ballast

For example,

a) Some defect in a rail joint may cause excessive pounding, as wheels pass over it. This continued series of impact loads causes a breakdown of ballast support under the joint ties. A low spot in the surface develops. Perhaps the joint begins to pump mud. It is not unusual for the track to develop a line irregularity at this spot. Depending on the position from which he/she is observing the track, the trained inspector might observe either the line or the surface defect first.



Ballast break down because of a pumping joint

b) Another situation in which loads become excessive is one in which the two rails do not have the proper cross level with regards to each other. The change in cross level could be gradual, unlike the previous example of the low joint. There might not even be a rough spot noticeable to anyone riding a train. If the cross level creates enough imbalance, then one rail will be receiving such a large part of the total load of each car passing over it, that a breakdown in surface, line or both can occur.

c) Roadbed instability can be another reason for the movement of track from its proper line and surface.

The problem may be due to soils, which are incapable of supporting the loads created by rail traffic.

Any of the causes of track misalignment that have been mentioned so far can be expected to occur on either curves or tangents.

The movement of trains on curves can cause another kind of line defect, one, which does not occur on tangents. Any object moving around a curve would follow a straight line, if there were not a restraining force, which keeps it on the curve.

Line Defects Because of Centrifugal Force

The force, which makes the object tend to move outward, is called **centrifugal force**. In the case of transit cars and locomotives, the centrifugal force is applied by the wheel flanges against the gauge side of the head of the outer or high rail. In most cases, the track structure is strong enough to resist the centrifugal forces applied against it. In those few cases where these forces exceed the strength of the track, several things can happen.

- The rail could either slide or roll outward
- The track structure pushing outward at points where the restraint provided by the ballast is weakest. (This has the effect of creating kinks or points of sharper curvature)

Considerable attention has been given to the principal ways in which irregularities in track alignment develop.

This has been done so that when you are faced with the job of correcting track alignment, you will acquire the habit of looking for probable reasons for this condition.

Sometimes it is necessary to correct not only the defective line, but also the condition, which has caused it, in order to prevent a reoccurrence.

I. Effects of Misalignment

Severe defects in line can cause the derailment of a train. The speed of the train is an important factor in determining how great the defect can be before derailment can be expected.

In other cases, with less severe line defects, such a defect can contribute to the cause of a derailment. The line defect, together with some other defect, in track or equipment, or some incident in train handling, can result in a so-called combination cause derailment.

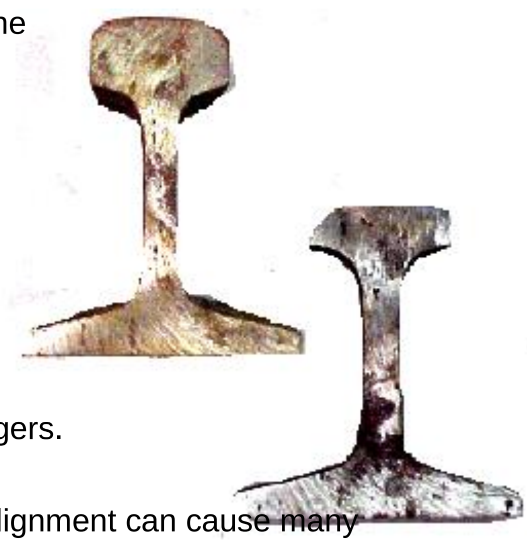
Track alignment defects, not severe enough to contribute to the derailment of equipment, can still create maintenance problems.

Any condition, which causes transit cars to be deflected from the straight line on which they travel, on a well-maintained tangent, creates additional stresses on both the track structure and the equipment.

Such forces are inevitable, to some extent, on any curve, but they are greater on a curve with alternating sharp and flat spots, than they are on a smooth, uniform curve.

When stresses caused by trains moving over poorly lined track becomes substantial; they can cause various problems to develop within the track structure.

- Stresses caused by defects in line can cause the line to become poorer yet.
- Another condition that can develop is gauge widening.



Excessive wear on the gauge side of the head of the high rail on curves is another possibility.

Shortening of the life of the ties can be expected.

The stresses caused by poor track alignment can also cause excessive wear on wheels and other equipment parts. Sudden lurches are uncomfortable and, at times, hazardous to passengers.

While it can readily be seen, that defects in track alignment can cause many serious problems, it must also be understood that track alignment, which approaches perfection, is seldom economical or practical to attain.

Most tracks always have numerous minor defects in line. Good maintenance practice involves keeping alignment between what is desirable and what is safe.

Spot surfacing or smoothing

Smoothing involves making a small raise to correct line or to correct and restore cross-level. It is sometimes called a **skin lift**.

Good judgement must be exercised in smoothing track during hot weather and in extreme temperature increases.

When smoothing or restoring prescribed elevation in a curve, each tie must be fully tamped under each rail to eliminate voids between the tie and the ballast section.

Tie cribs must be filled with ballast at any point that was disturbed by smoothing and track left in correct alignment.

The run-off made at the end of the day must be left in good cross level and alignment with a full standard ballast section.

J. Track Gauge Problems

So far this module has been concerned with track alignment. The remaining part of it will deal with track gauge.

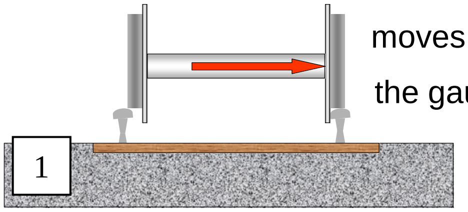
Problems involving track gauge are due to the gauge being either too tight (less than standard) or too wide (more than standard). Wide gauge is far more prevalent than tight gauge

.
The causes of wide gauge are very similar to some of the causes of irregularities in alignment, particularly those where lateral forces are placed upon the track structure by moving transit cars or locomotives.

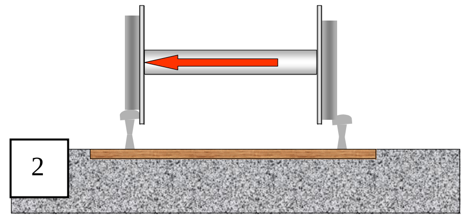
There are several different track conditions that can be caused by such forces and result in wide gauge. Wide gauge is seldom a problem on **tangent track.**

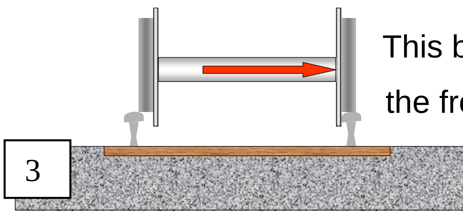
In the relatively few cases, where it does occur, it can usually be attributed to either extremely poor tie conditions. Some train handling incident which imposed large lateral forces on the track structure or a type of action that takes place within certain transit cars moving at high speed which is known as, **truck hunting.**

Truck hunting is when the flange on the wheels of a train, when on tangent track,

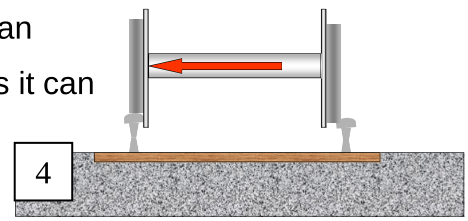


moves from one rail to the other, or side to side. Since the gauge of the wheels are 56 inches and track gauge is 56-1/2 inches or greater, there is room for the train to move from side to side even when the track is in perfect condition. The wheels, or trucks as they are also called, are hunting for a rail to hug just as they do in a curve.





This back and forth motion can be felt if you stand in the front of a rail car as it goes down tangent track. This side to side motion causes lateral forces to be exerted to the rails. In wooden tie areas this can cause the widening of track gauge. On concrete ties it can cause undue stress on the outside shoulder casting which may cause premature deterioration of the concrete tie.



Also this back and forth motion can cause alignment problems, such as rail kinks, during hot weather because of the high compressive forces in the rails.

Since most wide gauge occurs on curves, some understanding of the forces which moving equipment places on the track structure will be useful.

Centrifugal force has been explained previously. It has also been shown that tracks are superelevated on curves to help counteract the effects of centrifugal force.

A problem arises because the amount of centrifugal force changes considerably as the speed of the train changes. If tracks were superelevated so that when a train moves at maximum authorized speed, the axle loads were evenly distributed between the wheels on the high and low rails; problems might develop with slow-moving trains.

Under such conditions an excessively high part of the total axle loads would be placed on the wheels moving on the low rail. One result of this could be a rapid rate of flattening of the low railhead. In the case of jointed rail, surface would tend to break down quickly in the vicinity of the joints.

Certain types of equipment become unstable under such conditions and tend to derail easily. These circumstances make it necessary to compromise between what is desirable for trains moving at maximum authorized speed, and trains moving at low speed, when determining superelevation.

Therefore, most tracks have about 3-inches less superelevation than that which would produce a balanced condition for trains moving at the maximum permitted speed.

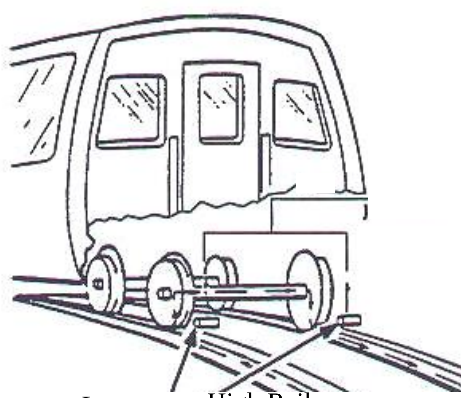
This causes a larger part of the axle load to be transmitted to the high rail by such trains.

- In most situations, the majority of trains tend to be moving at or close to the maximum speed, and relatively few trains at low speeds.

Another factor is the manner in which trucks tend to negotiate a curve. The leading wheel in the direction of travel tends to attack the high rail at an angle and needs to be constantly deflected by the high rail.

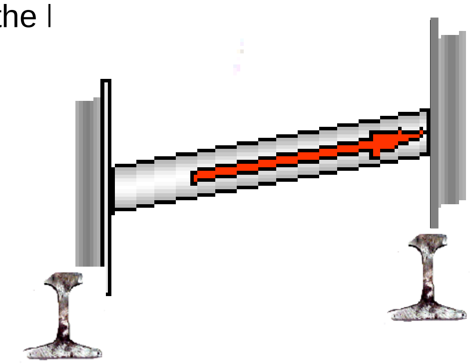
- This condition usually does not occur with the wheel on the trailing axle.

A careful examination of the drawing will show the relationship of each wheel in each



truck to each rail. The relationship in this drawing is for a car moving forward.

These two conditions, unbalanced superelevation and the **angle of attack** of leading wheels, create lateral thrusts against the l passing wheel.



When this angle of attack reaches a certain stage of wear on the gauge corner of the high rail in a curve, it can act as a ramp allowing the wheels of that train ride up onto the top of the railhead and derailing the train.

When this angle on the gauge corner of the high-rail of the railhead reaches 26° the ramping effect can take place. The railhead profile that MARTA periodicity performs allows the department to keep up with changes in railhead profile and take corrective action when needed. Such action can be rail grinding or rail replacement.

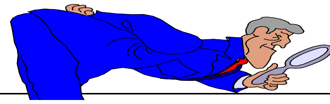
K. Curve Rail Wear

One result of these conditions is the gradual wearing away of the gauge sides of the railhead on the high rail.

This condition if itself, is rarely allowed to progress to the point that the track gauge is unacceptably wide.

- It can, however, in combination with other conditions result in unacceptably wide gauge.

When such wear occurs, the gauge side of the railhead becomes sloped. This condition makes the requirement for measuring gauge 5/8-inch below the top of the railhead of particular importance.



Another way in which gauge becomes wide is through a gradual lateral movement of the rail and pads or tie plate to the field side.

- This condition also occurs most frequently on the high rail of curves.

This is most likely to happen when a large proportion of the ties in the vicinity, are in the latter stages of their useful life. As the ties tend to soften due to the effects of aging, the spikes, lags, anchors or clip holders gradually lose their holding power. The spike, lags, anchor or clip holders holes or support areas begin to elongate under the repeated lateral thrusts of each passing wheel.

Gradually, the whole assembly of rail, tie plate or pads and spikes, lags and anchors moves outward. It may occur over a distance of several ties or it may be general throughout the entire curve.

Someone may watch this condition developing very slowly over a period of perhaps several years. This can lead to a false sense of complacency, in the belief that the rate of gauge widening will continue to be slow.

The problem is that the gradual reduction in the ability of the ties to hold spikes or clips may reach a point where some incident can cause a further widening of the gauge to happen, quite suddenly, resulting with the derailment of a train.

- The incident may be the movement of a car, which places abnormally high stresses on the track structure.
- The ties may be further weakened due to being saturated with moisture following a prolonged period of wet weather.

It is also possible for sudden gauge widening, due to a spreading movement of the rail and tie, to occur at a location where the tie conditions are quite sound.

- When this takes place, the cause is almost certainly due to some train handling problem or some abnormal equipment condition.

L. Rail Tipping

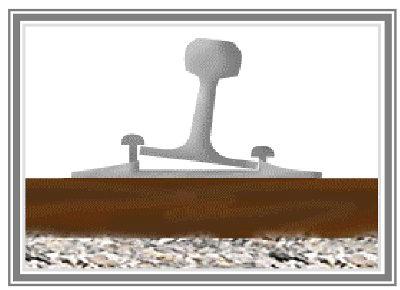
A gradual widening of the gauge can also be caused by a tendency of the rail to cant outward.

- This usually happens when the tie plates become plate-cut on the field side.

When this happens, the rail tends to be pivoted outward with an increase in gauge. This seldom progresses to the point where the condition of itself produces excessively wide gauge. It can, in combination with other conditions, result in excessively wide gauge.
Furthermore, the presence of such a condition indicates the presence of weakened ties, sprung or missing Pandral clips all need to be watched carefully.

Occasionally, a situation may develop where the rail is canting out of the rail seats or tie plates.

- This would indicate loss of holding power by the gauge side rail clips or spikes, possible intrusion of foreign material onto the tie seats, or heaving of the rail due to freezing conditions.



A situation may develop where a derailment occurs due to a rail rolling outward and it can be established that there was no prior canting of the rail, that there was no lateral sliding of the rail or tie plates and that the derailment occurred after the rail rolled outward.

In such a case, it is very likely that the forces, which caused the derailment, were excessive, and the track structure may have been in a condition generally accepted as safe.

Gauge.

(a) Gauge is measured between the heads of the rails at right angles to the rails in a plane five-eighths of an inch below the top of the railhead.

(b) Gauge shall be within the limits prescribed

The minimum gauge permitted, in all cases, is 4'-8" (56") for class 1 & 2 track. The principal hazard in tight gauge is the possibility of the wheels of lightweight equipment being raised up and possibly derailing.

Tight gauge in excess of normal tolerances encountered in track maintenance is not very common.

- It may be due to careless construction or maintenance.

Locations where tight gauge sometimes tends to develop are at rail crossings, particularly where the tracks cross each other at a relatively flat angle.

- This can be traced to forces created by rails running against the crossing and tending to distort major parts of the crossing.

N. Lining

Lining may be carried out at temperatures within the Working Zone. (Plus or minus 10^{o} from the P..R.L.T. of 80^{o}

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.
- The Force Free Temperature is the temperature of the rail without any forces placed on the rail. (tensile or compressive)

Example: A 1000-foot, 4^{o} 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 17.4^{o} F. Since this is out of the PRLT (Preferred Rail Laying Temperature), the curve would require de-stressing.

- When lining with jacks or lining bars, 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.

Technical Training

Track & Structures

Track Inspection Training

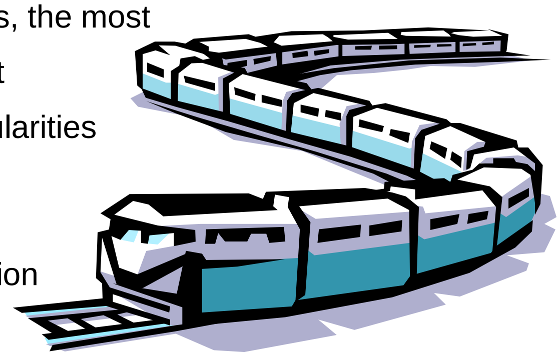
Stringline Training

Section 12

STRING LINE TRAINING

Many methods have been devised for computing the throws at each station on a curve from string line notes taken on the track.

Some are extremely complicated; some are only approximately correct and give results little better than the existing line.



With the exception of mechanical lining attachments, the most accurate method being used at the present on most railroads and transits for correcting alignment irregularities is the string line method.

Although nearly all, **out-of-face lining** with production units is now done with mechanical liners, there is still a need for an easy method of figuring curve throws for numerous small jobs.

Such occasions could be:

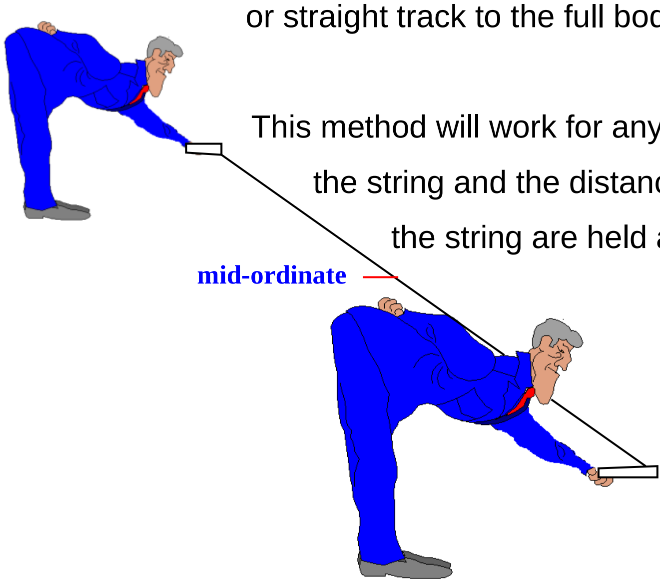
1. To increase side clearances, where close clearances exist.
2. When rail is to be removed and re-laid
3. To establish good alignment, when renewing a hi-rail access.
4. For final alignment when lifting slow orders for irregular line, such as at derailment sites.
5. Or any time raising or lining is not **out-of-face** and production machinery is not used, or is not available.

A. Explanation of Stringlining

Stringlining is based on the principle that a curve of uniform degree is in perfect alignment when the distance between the midpoint of a string stretched between any two points on the gauge side of the outer rail, and the rail itself, is the same at all points.

Distances

This distance is called the **mid-ordinate**, or simply **ordinate** for this method. The ordinates increase gradually and uniformly in the spiral, from zero at the tangent or straight track to the full body of the curve ordinate.



This method will work for any length of string, as long as the length of the string and the distance between the points where the ends of the string are held against the rail are not changed around the curve.

The only length of string, which will convert the ordinate directly to degrees, is 62 feet long. The conversion is: 1 inch equals 1 degree.

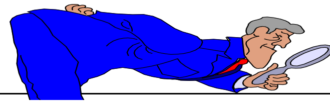
Cord Length

At **MARTA**, due to the curves being of a much higher degree than on a freight railroad, the cord length used is not 62 foot, but is a **31 foot chord**. With this arrangement, instead of a 62-foot cord, **a 31-foot chord** is used and the station lengths are shortened to **15.5 feet**.

When string line measurements are made on a curve, which has not been lined recently, the ordinates will not be uniform in the full body of the curve.

They also will not increase or decrease at a smooth, gradual rate in the spirals, but will vary.

The line of such curves can be improved greatly by throwing the track inwardly where the ordinates are larger than the desired average ordinate and outwardly where the ordinates are smaller than the desired average ordinate.



- Ordinarily you have no way of knowing just how much to shift the track at each point.

Stringline Stations

Station numbers are listed in Column 1; the original ordinates are entered in Column 2, opposite the station where they were measured. Column 3 is for gauge readings and the fourth column is for elevation while the rest will be explained in the calculations, which follow.

Since the method of figuring consists of trial and error, the rest of the columns may be used for further revisions if throws obtained in the first try are too large.

The right hand edge of the paper may be used for such notes as the location of obstacles to be cleared such as other tracks, signal masts, transitions, platforms and points through which the final line must pass such as hi-rail access, turnouts and bridges.

The second step is to plot the measured ordinates on a graph, which provides a complete picture of the existing line conditions.

- Graph paper expressly designed for this curve alignment purpose is available.

Elevation

To match elevation increases to degree of curve increases, the rate of elevation increase must be determined using the actual spiral length or the minimum spiral length whichever is longer.

Because our automatic surfacing equipment increases elevation in ¼" increments, the rate of increase will be figured using the ¼" rate of increase per required feet.

In the example,

- The actual spiral length is 248’ and the minimum is 62’.
- Using the actual spiral length of 248’ (which is longer than the minimum), divide the length in feet by the number of ¼” of elevation to determine the rate per ¼”.
- 248 divided by 4 (1 inch has four ¼”) = 62’ and is written as ¼” in 62’. This rate must be calculated for each spiral individually.

Conclusion

Of all methods available for lining track, the string line method will give the smoothest curve with the smallest throws.

It is as accurate as using a transit, but is more flexible and not nearly as costly. It requires only a string, a ruler, paper and pencil, and a few other simple tools.

Stringlining permits the revised alignment to be shifted to clear obstructions or to pass over the centers of bridges or other fixed points.

It is so flexible that it allows different spirals to be used at the ends of curves if needed or desirable.

ALL railroad personnel know that railroad tracks are composed of tangents connected by curves. Most of them know that the tangents are kept in line easily and that the rails are kept level with each other by means of a tool known as a **level.**

Most of them also know that the real difficulty is to keep the curves in line and the outer rail at a fixed and uniform elevation above the inner rail. This happens, so those transit cars will tilt inward, and thus offset the tendency for them to overturn outward due to centrifugal force while traveling around the curves.

B. Fundamental Principle Explained

When most of our railroads were built, engineering parties set stakes along the centerlines of the tangents and connected the tangents with curves, usually of fixed degree and radius.

As it was necessary that the rails on tangents be level across the track, and that the outer rails on curves be elevated a sufficient amount to offset the tendency to overturn.

This was a requirement that was obviously impossible to fulfill directly at the points where tangents and curves joined.

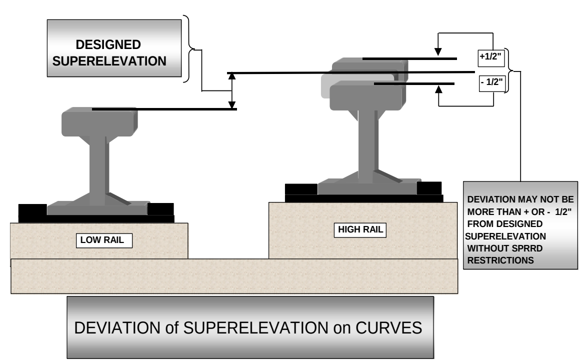
The rails could not be level and have the outer one raised at the same time.

Therefore, it was necessary to insert curves of varying radius between tangents and uniform curves, starting in the tangent and gradually increasing in degree of curvature until it equaled that of the body of the curve.

These **easement curves** are called spirals, and they are now considered an essential part of all curves in mainline tracks.

Track inspection and maintenance personnel know that a curve of uniform degree is in use when the distance between the midpoint of a string stretched between any two points on the gauge side of the outer rail, and the rail itself, is the same at all points.

Near the ends of the curve however, when a spiral is introduced, this distance, called the ordinate, decreases gradually and uniformly to zero when the entire length of the string is on the tangent.



- The foregoing is true, of course, only when the track is in perfect line throughout the curve.

When working complicated situations, it is a good plan for the computer (meaning the person who does the calculations, figuring throws, for stringlining) to be present to see that all side measurements needed are obtained and to give them actual knowledge of the conditions to guide them in computing the throws.

This is particularly true where **compound** or **reversed curves** occur in narrow rock cuts or tunnels, or under overhead structures.

- Under such conditions, side clearances are very important.

The computing person will know from experience where the shift is likely to be large, and he/she can get ample side measurement at these points to assure them self that the throws he/she figures will not be prohibited by insufficient side clearances.

The measurements should start about five to ten stations ahead of the beginning of the existing curve (in tangent track) and extend about the same distance beyond the end of the curve as found (again on tangent track).

- Also, frequently there is a **dogleg** in the tangent, which should be measured and allowed for in the correction.
- If the kink is in the same direction as the curve, it should be measured and recorded exactly as any other ordinate.
- But if it is in the opposite direction it should be measured with an offset string and recorded with a minus sign (-) before it.
- This will cause it to be corrected in the solution, and the track made tangent up to the point of the spiral.

Two persons hold the string against the gauge side of the head of the rail, at the bottom of the curve-worn portion, at two stations, while the third person measures the ordinate at the station half way between them.

If a recorder is present, he/she should check the reading on the rule also, as too much care cannot be taken in getting the original measurements correct.

- An error in reading the ordinate cannot be detected by the computer during computations, but it will be reflected in the final alignment, which will be found by trains, with the result that the track will be knocked out of line again quickly.
- It will cause a sharp or flat place in the curve, two stations long, which will be out of line in the middle by twice the error in reading.

C. Stretching the String

The string should be stretched tightly, but without force enough to break it, and the side of the string next to the rail should always be read, not the center of the string.

If variations are encountered, a tape must be used to locate the remainder of the stations on the curve. No short stations can be tolerated.

They must be kept within an inch of uniform length in order to produce satisfactory results.

The string should be kept at uniform tension and free from any contact with grass or weeds.

- The stringperson must watch to see that it is straight from end to end when the measurement is being taken, as the measurer or recorder at the middle of the string cannot tell if there is a kink in it.

They can tell if the proper tension is being maintained, however, by plucking the string upward after it has come to rest upon his rule, and then checking his reading.

- When the wind is blowing across the track, he/she may have to pluck the string two or three times at each station before he/she is sure he/she has the correct reading.

They should hold the end of their rule against the bottom of the curve-worn portion of the head of the rail, (5/8 inch below the top of the tail) the same as where the string is held.

- This is necessary because the throws for the revised alignment are to be set later by measurement from the same point.

Accuracy of measurement of the original ordinates is essential to obtain a true curve in the realignment stakes.

As soon as they have made their reading, the measuring person should so indicate by signal, so that all may move to the next station together.

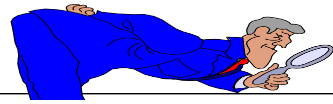
- This is repeated, one station (half the chord length) at a time, until a point, five or ten stations beyond the end of the curve is reached.

The recorder should number the lines on the sheet in advance, and should record each ordinate opposite the proper station number immediately after it has been measured and checked.

- Any delay in doing this may result in confusion or forgetting the figures.

They should note also the locations of any switches, frogs, beginnings and ends of bridges or aerial structures. Any narrow roadbed, signals, piers of overhead structures, track or hi-rail accesses or anything else that will prevent the lining of the track, or that will have to be moved before the track can be lined toward it.

Usually it is sufficient to estimate the locations of such obstacles to the nearest station. However, a surveyor's marker or station marker, or other fixed point of known location, should be tied in to the curve with a tape measurement so that proper record of the curve can be made.



Side measurement to each obstruction is taken with a tape on a return trip over the curve, the recorder indicating to the stringperson each measurement they desire.

- Also gauge readings need to be taken at each station on Direct Fixation.

Clearance from station platforms, adjacent tracks and retaining walls should be measured at each station on spirals and as often as necessary on the body of the curve.

- It is also necessary, on ballasted track, to measure track centers so that re-lining track will not move it to close to the other track. (Track centers are a minimum of 14' 9")

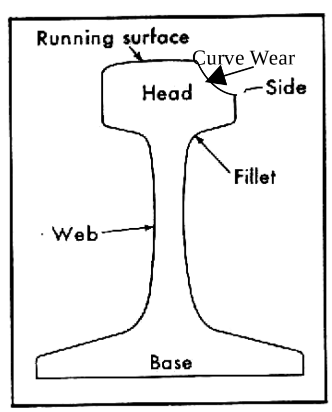
Care must be exercised also to obtain sufficient data to cover any change in location of the point of compound curve, if any, as such points frequently need to be moved ahead or back a few stations.

The existing elevation of the outer rail should be measured at every station on spirals and as often as needed elsewhere.

- Record the elevation tags at the station they are close to and confirm with crosslevel.

Any unusual curve wear on rails should also be noted, and the elevation measured at these points to see if the wear is caused by line or surface variations.

- It is good practice to obtain all information that may be useful while on the ground to avoid any delay later.



Excessive wear of the outer rail may indicate too much speed for the elevation, while a hammered condition of the inner rail indicates too much elevation for the average speed.

Of course, the service life of the rail must be taken into consideration also, but the above mentioned conditions frequently are the best indication of any change needed.

On grades, the average speeds over double or multiple tracks may be estimated closely, but on single tracks some compromise must be adopted as the speeds in one direction will vary considerably from those in the opposite direction.

While a long curve on a grade might have different speeds at each end, it is not advisable to vary the amount of elevation of the outer rail unless there is a distinct change of degree of curve also.

D. The Spiral

After the station numbers and the original measured ordinates, are recorded on the data sheet, inspection of the ordinate column will show that some of the ordinates at the beginning of the curve will be increasing in value.

- These are on the spiral or easement curve that connects the tangent with the body of the regular curve.
- The length of the spiral depends on the distance necessary to obtain the full elevation required for the degree of the curve and the speed of the trains, which will operate over it.

All transits have fixed rules for the amount of elevation for various speeds on different degrees of curvature up to a maximum amount, usually six inches.

- **At MARTA maximum elevation is 6".**

The minimum length of spiral should not be less that 1.2 times the authorized speed in miles per hour, multiplied by the number of inches of elevation used in the regular portion of the curve.

Example:

60 mph X 1.2 = 72 X 6 inch elevation = 432 feet

However, this length should not be less than 40 ft. per inch of rise, (40 ft. x 6 in. = 240 ft.) nor usually more than 80 ft. per inch (80 ft. x 6 in. = 480 ft.)

The first because at anything less than 40 ft. per inch, the rise is quite noticeable to those riding in trains.

And the latter because most transits use gradation marks on their track level boards for each ¼-in. increase in elevation, and ¼-in. per rail is about the practical limit for the trackperson to see with their level board.

If smaller rates of rise are necessary on account of speeds higher than 65 mph., adjustable levels should be provided and the trackperson required using them at each point where the elevation increases by ¼ in.

There are many possible spirals, but only one type is suitable for track work and that is a spiral, which increases in degree of curvature, from tangent to the degree of the regular curve, at a uniform rate.

- This means that the middle ordinates of the chords in the spiral increase as the distance from the beginning of the spiral increases, up to the value of the ordinates in the regular curve.

As the elevation of the outer rail also increases uniformly from level at the start to full elevation at the point where the spiral joins the circular curve, the tendency to overturn is exactly balanced throughout such a spiral.

- A perfect spiral has ordinates increasing as it progresses toward the body of the curve.

E. Adjusting Reverse Curves

Particular attention is given to passing the point of reverse curvature and the introduction of suitable spirals at this point, connecting the two simple curves with the least distortion of the simple curves themselves.

With a complete understanding of the solution of such problems, the string liner will be in a position to solve any curve that is likely to be encountered anywhere in track.

Up until now, all the instructions have applied to simple or compound curves – that is, curves in one direction, although they may be composed of parts with different radii.

In rough, hilly terrain, or when following the course of streams, it often happens that a curve in one direction will be followed by a curve in the opposite direction without any intervening tangent. These are known as **reverse curves**.

In the case of simple, one-way curves, the trackperson could extend half of the spiral at each end out on the tangent, but with reverse curves there was no tangent that could be used, so the distortion was necessarily very abrupt.

- As a result, the reversing point had to be protected by slowing down trains, and the increase in degree of the adjoining curves generally required a speed restriction also.

The reverse curves were necessary in the first place because of physical conditions, which usually still exist.

- The route may be in deep rock cuts or on side hills where the change in line to avoid the short spirals would be too costly or impracticable.

However, by use of string-lining methods, the best possible alignment can be found, utilizing every inch of available throw to the best advantage.

F. Measuring the Curve

In measuring up a reverse curve, the station numbering should be carried through continuously.

- When the ordinates have become zero or as near as possible to zero, three or more stations are carried across the track to the other rail and the work carried on as before.

After the last ordinate on one rail is recorded, a line should be drawn across the notes and **marked P.R.S. (Point of Reversed Spirals)** as it is essential to know just when the ordinates changed to the opposite rail.

In the case of simple curves or compound curves, the final figures in each column at the end of the curves must be zero.

- The zero in the sums column means that the central angle, and no more, has been used, and, the zero in the half-throws column means that the final station is exactly on the tangent.

Since the central angle is entirely used, the direction of the final tangent is parallel to that from which the original notes were taken, and since the final station falls on that tangent, the solution is a correct realignment of the curve.

With reverse curves following each other without intervening tangent, the above will apply only to the final station in a series of curves.

- The direction of the common tangent at each reverse point may, and probably will, be changed, and there may be a throw in either direction at each such point also.

The amount of change and the amount of throw may be varied at will to make the revised curves fit the local conditions and to obtain the best length and rate of spirals possible.

G. Seek Best Possible Results

The person who computes can well afford to spend several hours in studying such curves, trying time after time to make such slight alterations to his solution as will bring about the best possible results.

- It is obvious that the best results could never be obtained by the use of a transit in rough terrain where intersection of the tangents is not possible and the moving of fixed obstacles is impracticable or too expensive.

Every effort must be made to obtain spirals of suitable length, to make the body of the curve as uniform as may be possible. You also need to keep the degree of curve at a minimum, while keeping the throws inside the maximum limit to clear all fixed obstructions and to pass over the centers of bridges and through all other fixed locations.

No curve should be staked until the person computing is satisfied that he/she has obtained the best possible solution and that it meets the above requirements at every station.

- Needless to state, this requires patience and perseverance, as each curve is a problem by itself and can be solved only by repeated trial and correction.
- The work, however, is very fascinating, and the computer has a feeling of real satisfaction with the solution of each problem.

H. Length of Spiral

Once the superelevation has been established, the third step is to determine the length of easement curve.

- The information necessary is the superelevation and the maximum train speed.

Once a track person becomes familiar with the track charts they can read off the values rapidly and with confidence.

- The charts, to be of value, must be of such size that they may be used conveniently in the field.

The clipboard, used by most inspectors, is large enough to give charts, which may be read with sufficient accuracy, yet small enough to be carried in the field without difficulty.

I. Materials Required to Stringline:

Needed Material

- Two String line Paddles
- Sixty two (62) feet of stringline chord
- String line Reader
- Carpenters ruler
- One Hundred (100) foot Tape measure
- Paint Ball Markers
- Track Charts
- Paper and Pen to record readings

Additional Items;

- Gloves
- Flashlight
- Lumber Crayon,
- Extra Cord
- Something to cut the Cord,

J. Marking Stringline Stations;

Starting Stringlining;

In order to properly mark the string line stations you must know where the **Tangent to Spiral (T.S.)** starts.

- In all measurements made on the track, work from Five Points Station out.
  a) This means that your first number will start at the end of the curve that is closest to Five Points.
  b) All other numbers will then increase or get larger as you go away from Five Points.

Once T.S. has been determined, go a minimum of ten (10) stations into the Tangent marking string line stations.

- This will ensure that there is a smooth transition from the Spiral to the Tangent.
- Stations are marked fifteen and a half feet (15 ½) apart.
- This will make for a thirty one-foot (31) chord length.
- Use a Paint ball marker to mark stations and station numbers.
- A line on the field side of the ball of the rail to mark the station.
- Put the station number on the gauge side of the rail at the base.

It is best to use your Tangent to Spiral as a station location, and then go ten stations into tangent and then to number the rest of the curve.

Where to set stations

Starting with station 5 or 10 exactly on T.S.

- This puts 5 to10 stations on the Tangent in order to have the proper run-in to the Spiral.
- This will help to eliminate what is commonly referred to as a **DOGLEG.** A DogLeg is a misalignment of the track where the Tangent and the Spiral meet.
- Putting the mark on the Tangent to Spiral spot helps to set the location of the curve for the computer program that is used to figure the throws for that curve.
- Getting the exact location of everything on the track is also important.

- Mark the stations with a Paint Ball Marker with a slash on the outside top part of the ball of the rail. Also write the station number on the base of the rail.
- Continue to mark stations throughout the remainder of the curve.
- There is no set number of stations.
- The length of the curve will determine the number of stations.
- Start with zero (0) and work your way up.

String line Data Sheet

Mark the Data Sheet when these areas are reached;

1) Tangent to Spiral (TS),
2) Spiral to Curve (SC),
3) Curve to Spiral (CS)
4) Spiral to Tangent (ST)

If T.S. starts at station # 10 then at station #10 on the String line Data Sheet put the letters T.S. If S.C. begins at station #25 then mark that station with S.C. Continue with this for C.S. and with S.T.

Any obstacles or Survey Markers you come across in this curve, write down its location (such as SR 172+90 a Hi-Rail Access at Oakland City Station) at the string line station it is near.

Write down the location (such as SR 169+30 the abutment at the south end of the West End aerial structure) when the station is at or near an abutment. Note how far away from that station in feet that marker or obstruction is.

Any transition from one type of track structure to another also needs to be noted. (DF to Ballast or Slab Track to Aerial Structure)

K. Taking String Line Readings

When Taking Stringline Readings

(a) When taking string line readings it's important that the measurements are taken consistently at the same spot on the ball of the rail.
(b) That point is 5/8 inch below the top of the rail.
(c) This is accomplished with the String line Reader.
(d) It is a crosslevel with a metal tape measure attached to the foot
(e) Never let the string touch the ruler
(f) The string is to be on top of the ruler
(g) Put it as close to the ruler as possible, but again, do not to touch the ruler.
(h) In order to keep the string from touching, your paddle holders will need to adjust the location of their paddles, up or down on the ball of the rail.
(i) Start at station one (1) and continue to the end of your stations.
(j) Making sure that you write down all the readings.
(k) All readings are in sixteenths of inches.
(l) String line paddles keep the string one (1) inch from the Rail
(m) The one (1) inch mark on the ruler is your zero point.
(n) All measurements over an inch are plus numbers
(o) Everything below an inch is negative numbers.

Negative Readings

a) If your ruler reads ¾ of an inch then that equals to a negative four (-4).
    - We count in sixteenths of an inch
b) Do not start counting at the end of the ruler
    - Start at the one (1) inch mark and count backwards.
c) The count is negative four (-4) sixteenths back from the one (1) inch mark of the ruler.
    - Remember everything below the one (1) inch mark is a negative number.

Positive Readings

If everything below the one (1) inch mark on the ruler are negative then everything over one (1) inch are positive numbers.

a) If the reading is 1 ¼ inches, then your reading will be a plus four (+4).
   - Because 1-¼ inches is plus four (+4) sixteenth of an inch above the one (1) inch mark.
   - Remember the 1-inch mark on the ruler is the zero point for stringlining.
   - The paddles keep the string 1-inch away from the rail.

b) The readings that you take will vary throughout the curve.

c) Sometimes making large jumps, plus or minus.
   - This is to be expected.

d) The track will have bulges and flat spots throughout the curve.

e) That is why we are taking these readings, so that we can make the curve as smooth as possible.

Starting Stringlining

a) When starting the String line readings, put the first paddle on station zero (0)

b) The second paddle will be on station number two (2), taking the reading on station number one (1).

c) Once each station has been read, such as station number one (1) move the paddles ahead one station each.

d) Now the paddles will be on stations one (1) and three (3)

e) Take readings on station two (2).

f) Continue this moving ahead, one station at a time until the entire curve is completed.
   - Always take your time in reading each station.
   - The more accurate the readings the better the curve will line.

L. Figuring String Line Throws

When Figuring Stringline throws

That for every throw, positive or negative, ½ of that throw will be added or subtracted from the station right before and right after that number.

Having three readings in a row and they are, 7, 4, and 8, and wanting to correct the alignment in this area, add 2 to the reading that is a 4.

- This will make the 4 a 6 (because 4+2=6).

Now that the reading has changed the 4 reading to a 6, subtract ½ the throw number from the 7 and also ½ the throw number from the 8 (7-1=6 and 8-1=7).

- For ½ the throw of 2 is 1.

In making just one (1) throw it will have effected the readings on each side of it.

- Now the new readings will be 6, 6 & 7.
- This is a smooth piece of track.

No readings should be more than a two (2) sixteenth of an inch different.

What was done is to take readings that were 3/16 and 4/16 of an inch off and realigned it that it's only now 1/16 of an inch off. Well within our limits.

Positive Throws

Always remember

- **Throws must be made in even numbers, 2,4,6,8 etc.**
- **Never in odd numbers, such as 1,3,5,7 etc.**

As seen from the readings above we go from 7 to 4 to 8 to 4 to7. The alignment is not good, with changes occurring at each station too great to leave.

- Two throws are needed in order to smooth the alignment.

This is what happened.

The 4 needed to be raised,
Adding Plus Two (+2) the 4 becomes a 6

As stated before

If adding to one number, then subtract ½ that throw number from the number above, and the number below that number.

- When that is done to the 7 it becomes a 6 and the 8 becomes a 7.

Now go to the other 4

Adding +2 to that number, It becomes a 6.

As before subtract ½ the throw number (1) from the 7,making it a 6, then subtract ½ the throw number (1) from the 7 to make it a 6.

Why do we subtract or add ½ the number from the numbers above and below the station thrown?

- When you move the track in one area you change the reference point for the other stations that are above and below it.
- Since the string line paddles will be set on the stations that will be moved, if it's moved in or moved out, that will change the reference point for measuring each station on each side of your throw.

Negative Throws

Above was how to make positive throws, now take a look at making negative throws.

Stations	readings	throws ( )	new readings
1	5	+1	=6
2	8	(-2)	= 6
3	4	+1 = 5 +1	=6
4	8	(-2)	=6
5	5	+1	=6

Always remember,

a) Throws must be made in **even numbers,** 2, 4, 6, 8 etc.
b) **Never** in odd numbers, such as 1,3,5,7 etc.
c) Even numbers are easy to read on a tape measure.
   - It is impossible to throw just 1/16 of an inch.
   - It's so small, just holding the paddles different can make that much change in the readings.

From the readings on the previous page, the changes are from 5 to 8 to 4 to 8 to 5.

This alignment is not good

With changes occurring at each station too great to leave. Two (2) throws are needed in order to smooth the alignment.

- The 8 needs to be lowered, subtract 2 from the 8.
- Then the 5 becomes a 6.

As stated before

When subtracting one throw number you must add ½ that throw number (1) from the number above, and the number below.

- When that is done the 5 becomes a 6.
- The 4 becomes a 5.

Now for the other 8

Subtract 2 from that number and it becomes a 6.

- As before add ½ that throw number to the 5, making it a 6.
- Then add ½ of that throw number to the 5 to make it a 6.

These rules apply to any set of numbers you have.

The throws were small. Any throws that we make, will need to be worked out on a sheet of paper.

Or given to your foreman to put into the computer.

- The computer will work out the necessary throws.

Its important to give the foreman all the information needed to line the track.