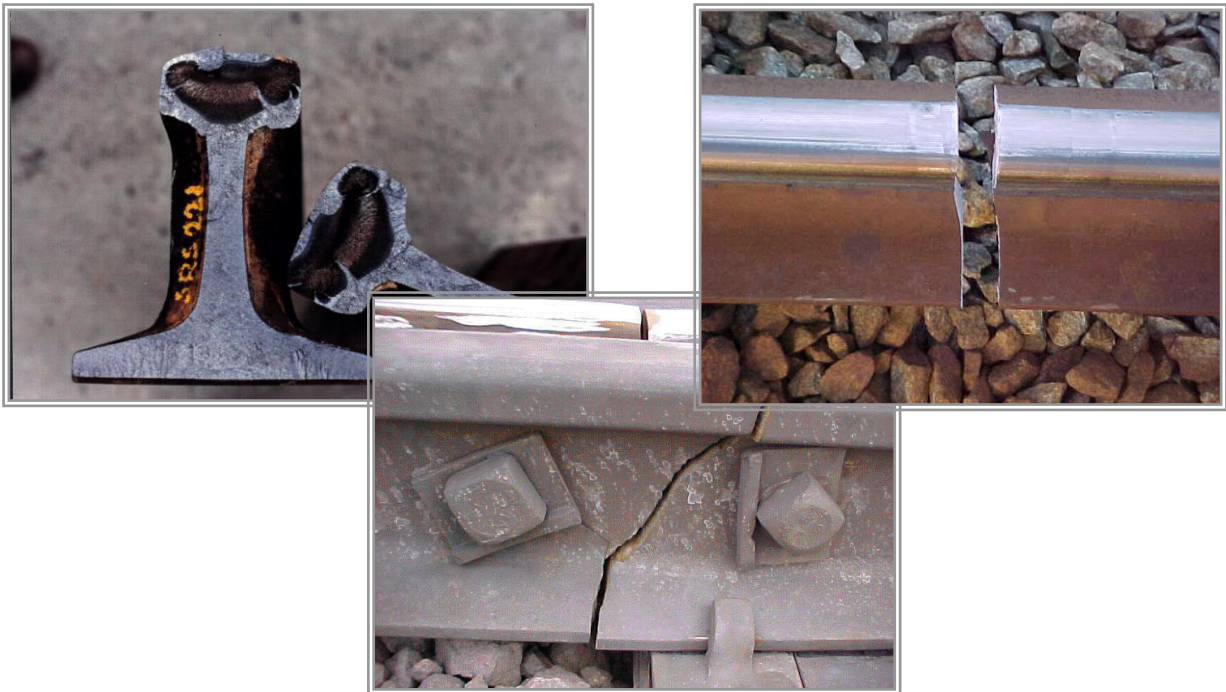




Track and Structures

Track Maintenance Training



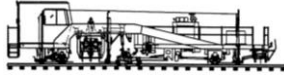
Rail Technology

MODULE

Rail Defects

Metropolitan Atlanta Rapid Transit Authority

Infrastructure Training



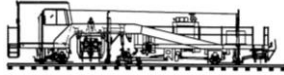
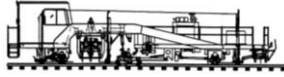
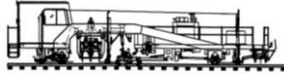


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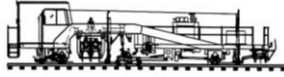
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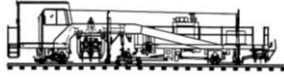


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Rail Defects

Introduction

Rail Defect training will provide a review of MARTA and FRA standards and practices. At the end of this module, students will be able to properly identify rail defects, causes of defects and how to use the remedial action table in accordance with MARTA and FRA maintenance procedures.

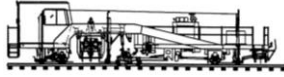
Requirements

Test scores must be 80% or higher on all written evaluations. Only one retest will be allowed on any written evaluation without additional training. All MARTA Track and Structures personnel must demonstrate knowledge of MARTA and FRA procedures and the ability to identify rail defect areas.

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

Learning objective

At the end of this module you will be able to use the Sperry Rail Defect Manual and FRA Track Safety Standards book to identify all the rail related defects found wayside and must have the ability to define what action needs to be taken according to MARTA and FRA standards.



Section Objectives

Describe visual defects.

Describe surface defects and name all nine and describe each.

Describe internal defects and name and describe them.

Describe web defects and name and describe them.

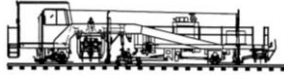
Describe base defects and name and describe them.

Describe weld defects and describe the two different processes used to make welds.

Demonstrate the ability to correctly use the Remedial Action Table found in the FRA Track Safety Standards.

Primary role of Rail Defect training

The primary role of the Rail Defect Training is to define all rail related defects and to be able to locate and find rail related defects found in the rails and in the turnouts.



Rail Defects

From the earliest days of railroading, maintenance of the right-of-way has been one of the greatest challenges of the railroad industry.

- Prevention of service failures of rail in track.

The causes of rail failures were and are many.

- Injury or death of crews and passengers.

Cast iron rails made long ergo crystallized and cracked under the strain of severe climatic changes or sudden shock loads.

- Cold weather.

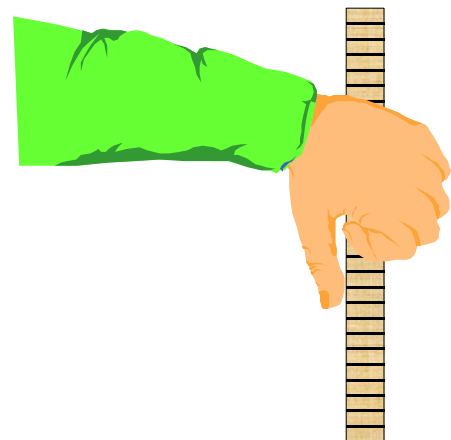
The present day steel rails manufactured by the basic oxygen or electric furnace process, although vastly superior to the older types of rail in both strength and wearing quality, still develop defects.

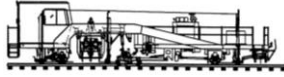
A. Running Surface

Rail surface defects, which include corrugations, corrosion, engine burns, surface spalling, etc., represent a significant class of rail anomalies that directly effect 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.





1. Rail Surface Condition Measurement Tools.

The following tools are recommended for the rail surface condition inspection (note, only one of the three listed below is required).

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.

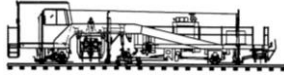
Dial Indicator and 36 inch Straight-edge



- 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.



2. 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.

When the rails are no longer considered to be in suitable condition for the demands of high speed, main line traffic, they are often re-laid or reused on a branch line or in a yard track. This means that most rails have a very long life, before they are finally scrapped. This is not a practice used at MARTA.

With more continuous-welded rail (**CWR**) being laid each year, defects in both plant and field welds of rails, are becoming more frequent.

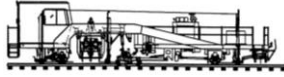
- Rail weld defects usually progress from inclusions or slag entrapments at the weld interlace.
- Some longitudinal weld defects in the mid-web area may result from residual stresses in the weld area or stress risers resulting from improper removal of upset metal.

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**.

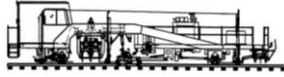
The relatively small amount of friction developed by the wheel-to-rail combination permits the hauling of large tonnage's with minimal locomotive power.

- 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.



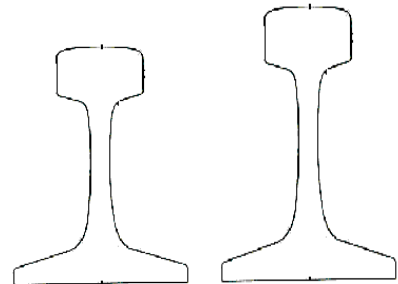
3. Trend Toward Heavier Rail Sections

Throughout most of the history of railroads, there has been a continuous trend towards use of heavier rail in response to heavier freight cars and locomotive power.

- Since the serviceable life of rails is so long, many older rails still in track today were designed for lighter wheel loads.

As train speeds and freight car weights have been increased since the beginning of the twentieth century, the size and weight of rail has been increased to meet the demands of increased train dynamics.

Rail heights, primarily in the web, have been increased to offer greater stiffness for better riding qualities of trains at higher speeds.



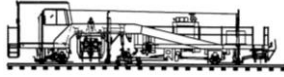
Rail weight has been increased, especially in increasing head depth, to extend rail life under heavy freight traffic.

Rail sizes of 130 pounds or greater have been adopted since 1915 with 132- and 136-pound rails being very common today. According to the AAR, 60.8 percent of all rails in Class 1 railroads is of 130 pounds or heavier.



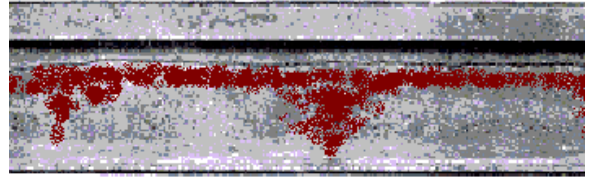
Most rails are eventually scrapped because of wear of one or more types.

- This includes such things as rail end batter, vertical or horizontal bending, curve wear from abrading by wheel flanges on the high or outside rail of curves and railhead flattening and tipping.



A smaller number of rails must be replaced before becoming sufficiently worn because of the development of a defect within the rail, which makes them unsuitable for further service.

Some types of defects originate with a flaw that is within the rail at the time of manufacture.



- Most of these flaws are small and remain undetected for many years.

Eventually, after a great deal of traffic moves over the rail, the flaw begins to spread.

- In other cases, a condition develops on the surface of the rail directly related to severe service conditions to which the rail is exposed.

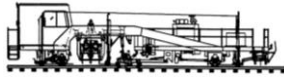
Sometimes cracks originate from some of these conditions on the rail surface. In other situations, a rail simply cracks or breaks under conditions that make it difficult to determine the cause.

Although some rails break suddenly, in the vast majority of cases, a defect develops slowly.

- A well-trained eye can detect some defects before the rail breaks.

Other defects can be located only with special equipment. Some defects are more dangerous than others hence, different remedial action is required.

- Track personnel needs a good working knowledge of the different types of rail defects and what to do when confronted with them.



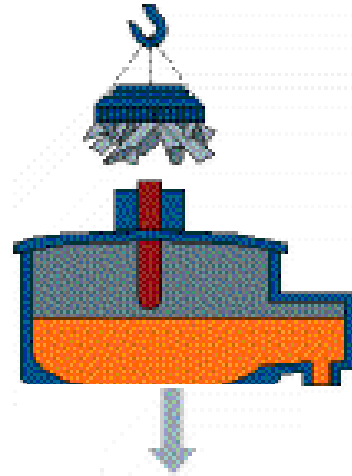
4. How Rail is Made

(a) DC Electric Arc Furnace

Direct current technology provides PST with the best available means of making steel.

- Advantages include large heats, more heats per day, greater consistency and greater reliability.

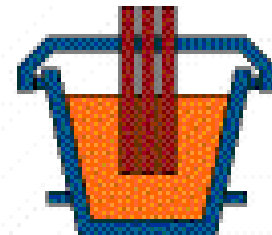
This results in significantly better steel quality. Also, the eccentric bottom tapping promotes more efficient tapping and cleaner steel.



(b) Ladle Arc Reheating Furnace

This furnace performs additional steel refining by providing excellent temperature control and precise chemical adjustment capabilities.

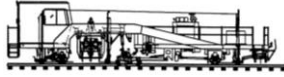
- It provides steel to the Jumbo Bloom Caster at the correct temperature, chemistry and time.
- Argon stirring, through a porous plug in the bottom of the ladle, promotes the homogeneous mixing of additives to the ladle, assists in temperature control and promotes the flotation of non-metallic inclusions.



(c) Tank Vacuum De-gasser

Most importantly, vacuum de-gassing lowers the hydrogen content of the liquid steel.

- Argon stirring during de-gassing also assists the removal of hydrogen and further improves steel cleanliness.



Clean steel making practices, combined with the benefits of the Ladle Furnace and Vacuum De-gasser, means that the Jumbo Bloom Caster receives steel with significantly improved internal cleanliness levels, correct chemistry and correct temperature at the correct time.

- This results in improved rail fatigue life.

(d) Continuous Jumbo Bloom Caster

The Jumbo Bloom Caster produces the cleanest rail steel possible, because it eliminates re-oxidation by completely shrouding the molten steel from the atmosphere, which prevents the formation of harmful non-metallic inclusions.

Rapid solidification affects the inclusion distribution.

- Those that remain tend to be small, globular and more finely dispersed.
- Also, surface quality is dramatically improved.

The resultant blooms are world-class quality, with a sound interior and excellent surface – the ideal starting material for rolling mills.

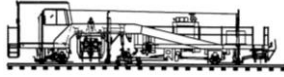
- Special casting practices and processes, developed by a dedicated team of researchers and caster specialists, have further improved the internal cleanliness of the blooms by floating out additional remaining impurities.

(e) Soaking Pits

The soaking pits enable the hot connection of the continuous cast bloom to the rolling mills.

Hot connection eliminates the potential thermal cracking problems associated with cooling blooms to ambient temperature and re-heating.

- Also, the Soaking Pit Control System has been updated completely with the latest computer control technology.



(f) In-Line Head Hardening

This unit, a 101-meter (331 feet) in-line process at the exit end of the 28" Rail Mill, uses the latent heat from the rolling process.

- The system is fully computerized and uses water sprays to slack-quench the rail.

The resultant product is composed of pearlite with fine inter-lamellar spacing, which provides rails with excellent hardness and improved wear resistance.

- Residual stresses are low, and straightness is excellent.

Produced by this technology, rails used in heavy-haul service in the U.S. are performing to world-class standards.

(g) Controlled Cooling

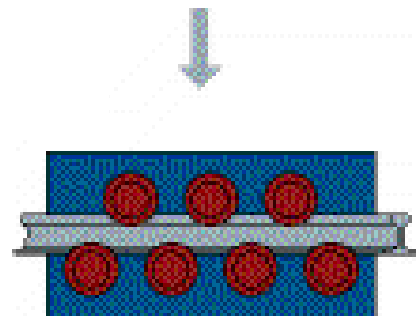
Rails are cooled in long-length, insulated boxes to ensure the removal of any remaining hydrogen gas.

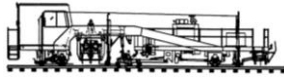
- While the reduction of hydrogen levels through vacuum degassing reduces the need for control cooling, the industry continue to use control cooling of the rails to further reduce the risk of hydrogen damage.

(h) Roller Straightener

Rails are put through a two-plane roller straightening operation.

- Load levels are continuously monitored to ensure the production of straight rails without mechanical damage.

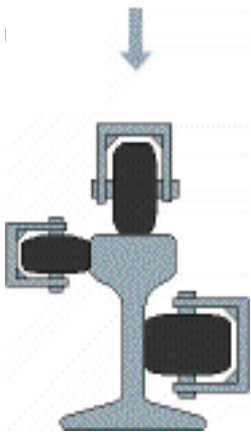




(i) In-Line Rail Inspection

Includes utilization of the following procedures and instruments:

- Visual Inspection Station
- Ultrasonic Twist Gauge measures elapsed time between two sound beams directed on the base of the rail.



DAPCO 300 Ultrasonic Unit is state-of-the-art, fully computerized with an automatic paint spraying system, and utilizes an array of transducers mounted in neoprene wheels, strategically placed around the rail to monitor internal quality.

Laser Straightness Gauge performs a three-point measurement of deviations throughout the rail body.

- Laser beams are directed at the head of the rail and data is monitored continuously by a computer.

Optical Section Measurement Unit automatically measures key dimensions of the finished rail. Data is continuously collected and analyzed by a computer to aid section control and allow further reduction of section variability

5. Service Failures

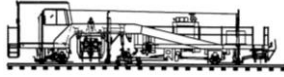
Defective rails may be discovered in various ways. At its worst, a rail that fails in service is found after it has caused a derailment.

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.



6. 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.

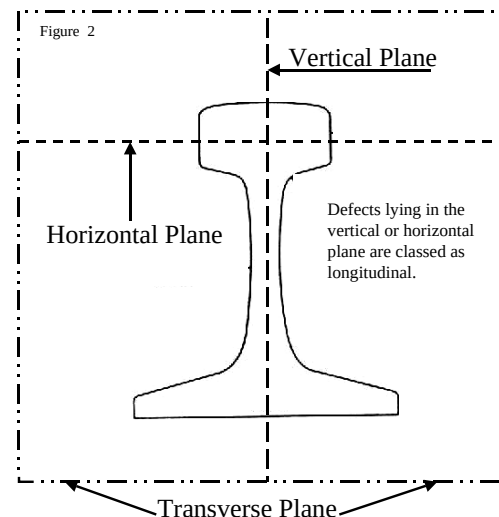
Surface defects may simply enlarge under the batter of passing wheels, or may furnish the focal point for an internal separation.

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.

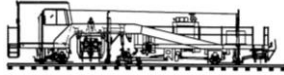
B. Visual defects

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.

C. Railhead Surface Defects

1. 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.

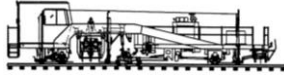
- This type of condition is seen on heavy freight operations.

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 rough



2. 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.

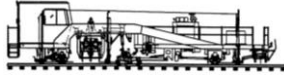
- The continual passage of the heavy wheel loads causes it to grow.
- Also higher train speeds and increasing depth of the flat spot accelerate growth.
 - 1) A flattening and widening of the head for several inches, with the entire head sagging.
 - 2) Small cracks in the depression on the running surface.
 - 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.

3. 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.

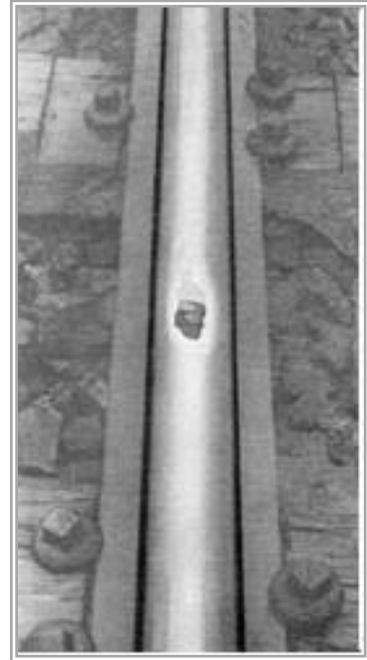
- The locomotive driving wheel overheats and displaces wheel tread metal on the running surface.
- The burn does not actually grow, however, the damaged area may gradually chip out and roughen under repeated traffic.
- The engine burn is also known as wheel burn.



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.

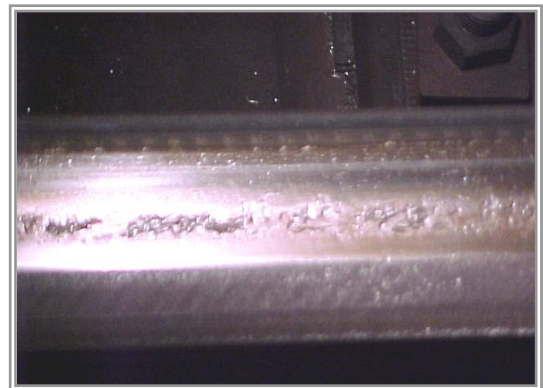
This can be an effective temporary measure until the burn can be welded or the rail replaced. Depending on the severity of the depression, a slow order may be appropriate to reduce impact stresses until the condition can be corrected.



4. Flaking

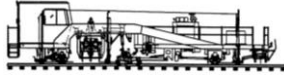
Flaking is a rail defect consisting of the gouging of metal on the railhead; it is indicated by small chipping and cavities.

- 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.

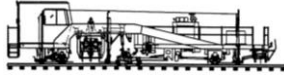
5. Head check

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-degree 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.



6. Flowed rail

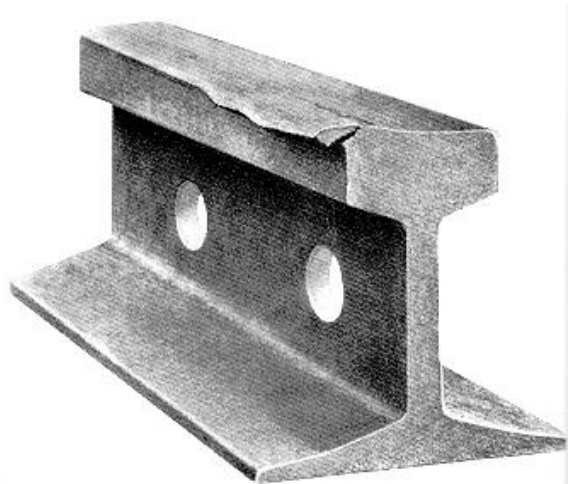
A flowed rail defect consists of the rolling out of the tread metal beyond the field corner, with no breaking down of the underside of the head.

- 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.



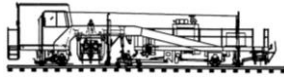
Appearance of flow in rail Photo - Section of rail with head flowed to field side, some of lip cracked or broken off

- 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.

7. 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.

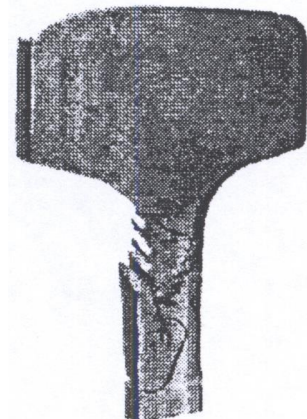


Metal that splashes on the side of an ingot mold may cool and oxidize to some extent before busing with the liquid metal.

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.
 - 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

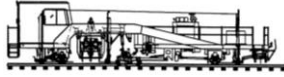


Mill defects are a serious defect if they are deep or large enough to cause the development to increase.

8. 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 apparent only after the railhead is broken or sectioned.

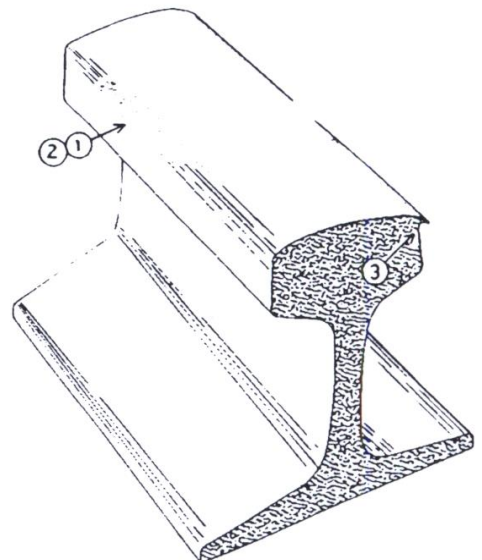
The exact origin of shelling has not been definitely determined.

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.

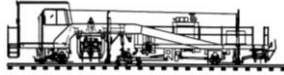
The growth depends on the loading. The separation progresses in the path of least resistance. Shelling may turn down to form a transverse separation, in which case the defect would be classified as a detail fracture from shelling.



- 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.



9. Slivers

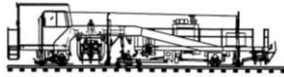
Slivers, sometimes called rail sliver, is a rail defect consisting of a thin tapered mass of metal that has separated from the surface of the head, web or base of a rail.

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.

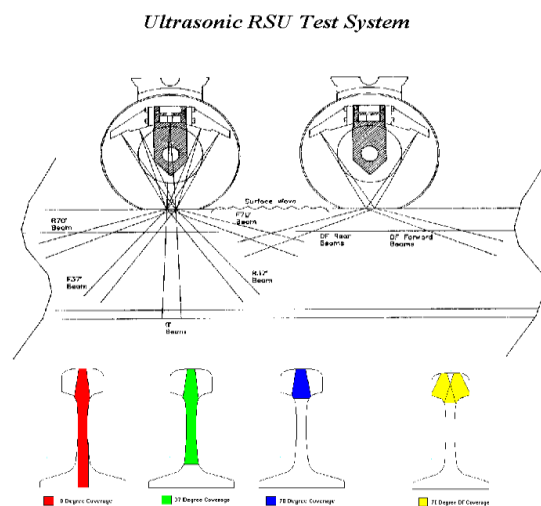
Internal rail defects are best detected using ultrasonic and induction rail defect equipment.

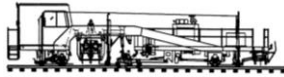
- The most widely used type of equipment is the **Sperry Car** which is operated by Sperry Rail Services to detect the rail for such things as corrugation, engine burns, high & low welds and other rail defects.



Sperry equipment locates defects that are similar to those that result in many service failures. Frequently, the detection equipment located 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 **FRA Track Safety Standards** effective September 21, 1998.





1. Transverse Defects in the Railhead

A transverse defect is any one of a group of defects which progressive fractures that occurs 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

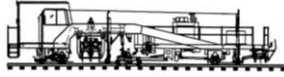
The transverse defects will generally grow within the railhead until the rail is sufficiently weakened to permit a complete break, under load, across the head, web and base of the rail.

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.

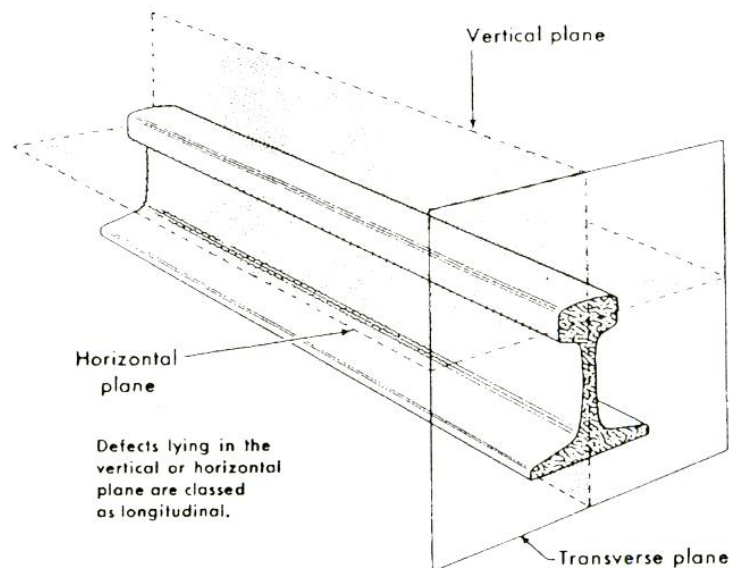
Numerous gauge cracks are often present, but should not cause suspicion unless a single crack extends much farther down the side and much farther across the running surface than the other cracks.

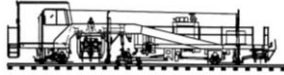
A horizontal crack in the side of the railhead which turns upward or downward at one or both ends and is usually accompanied by bleeding.

- 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 tipper 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.





2. Compound fissure

MARTA Track Safety Standards definition for compound fissures

Compound Fissure means a progressive fraction originating in a horizontal split head which turns lip or down) in the head of the rail as a smooth, bright, or clerk surface progressing until substantially tit a right angle to the length of the rail. Compound fissures require examination o 'both./aces of the fracture to locate the horizontal split head, from which they originate.

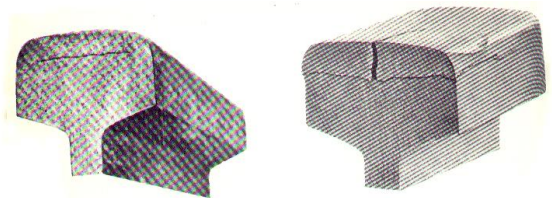
3. Development of compound fissures

An internal longitudinal seam, segregation, or inclusion with the railhead starts the development or 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.

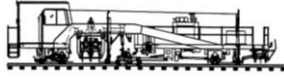
- Also, unlike the transverse fissure, there is no nucleus within the defect.



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.





4. Detail fracture

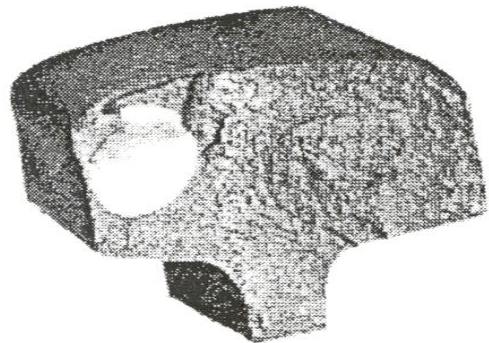
MARTA Track Safety Standards definitions for detail fractures

Detail fractures means 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.

5. 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.

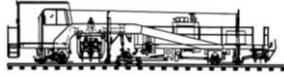


It is possible for a detail fracture to grow quite quickly. Failure often takes place before there is any visual evidence of the defect. Like the fissures, detail fractures lead to a complete transverse break across the entire rail.

6. 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:

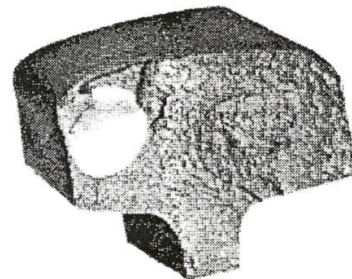
- Tendency to occur several places in the same rail
- Service failure is the result of a complete break of the rail across the head, web and base of the track.

Detail fracture originating from head check on gauge side

7. 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.

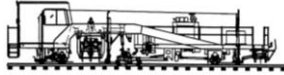
After some distance, the crack turns downward and inward to form a transverse separation.

- 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.



8. 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.

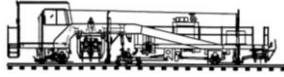
The growth is normal to a size of ten percent and is often rapid or sudden prior to complete failure of the rail section.

- 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 atypical detail fracture.
- Service failure is a complete break of the rail across head, web and base.



9. Engine burn fracture

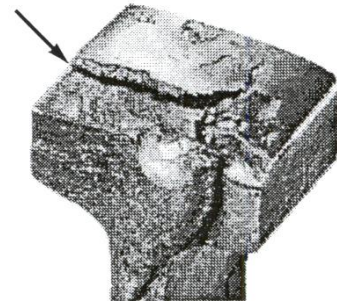
MARTA Track. Safety Standards definition for engine burn fracture

Engine burn fractures means 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.

10. 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.

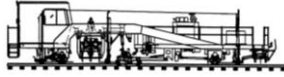


If severe slippage of train or locomotive wheels occurs, each driving wheel will create a surface defect on the head of the rail on which it is supported.

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.

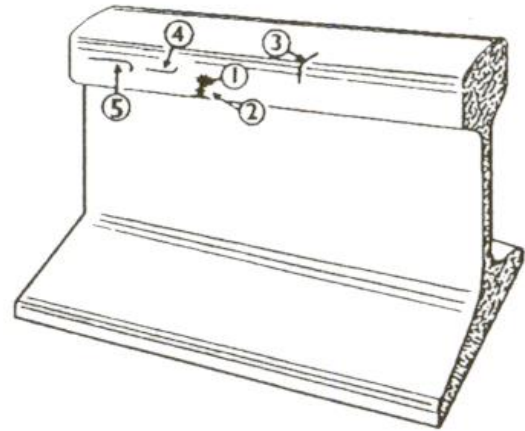


This rapid heating and cooling of the surface metal can cause a horizontal separation to occur just under the surface of the railhead. In addition, an irregularity is left in the surface of the railhead.

- This causes pounding as each wheel moved over the burn.
This combination of circumstances can cause growth of the horizontal separation, which can turn downward and form a transverse separation.
- See the MARTA Track Safety Standards for required remedial action.

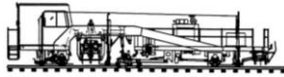
Although failure sometimes takes place before the defect becomes visible, one or more cracks may be visible on the rail surface in the vicinity of an engine burn, prior to failure. The above picture illustrates the appearance of typical cracks that develop on the surface as an engine burn fracture grows.

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.



11. Gauge side

- 1) A hairline cracks 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.

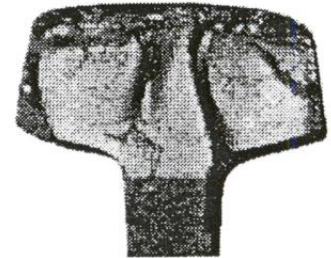


12. Field side

- 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.

13. 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.



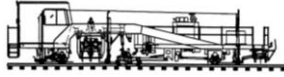
A welded burn fracture is sometimes the result of insufficient **wash out** or cleaning of an old engine burn prior to resurfacing by welding and this essentially fails to eliminate thermal cracks created by the original driver burn.

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

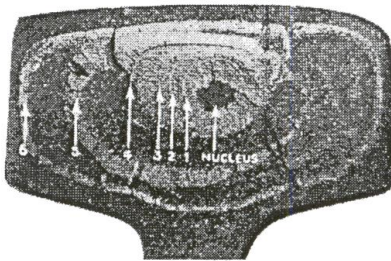


14. Transverse fissure

MARTA Track Safety Standards definition for transverse fissure

Transverse Fissure means 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 or defects are the crystalline center or nucleus and the nearly smooth surface of the development which surrounds it.

15. 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.

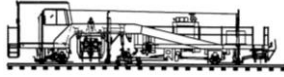
This nucleus may have been caused by a shatter crack, a small inclusion of an impurity with the steel or a blowhole.

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

Rapid growth
(Arrows indicate growth rings)

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.



Most railroads still have substantial quantities of rail in track that is not control cooled. Such rail can be identified in two ways.

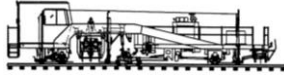
- One way is by the absence of the letters CC on the brand that identifies the rail as control cooled.
- The other way to identify such a rail is by the date of manufacture. Rails manufactured prior to 1937 usually are not control cooled.

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 be 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.

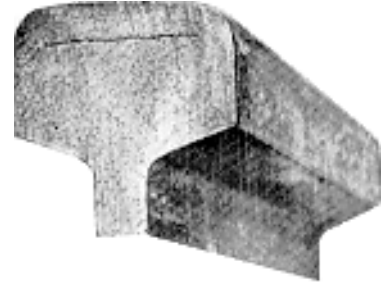
In most cases, there is not visual defect until the rail actually breaks.



- When the rail does break, which is a complete transverse break across the entire rail, it is highly dangerous.

16. 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.

17. Horizontal split head

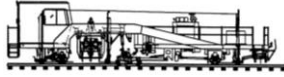
MARTA Track Safety Standards definition for horizontal split head

Horizontal split head means 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 has a crack lengthwise of the rail when it reaches tire side of the railhead.

18. Development of horizontal split head

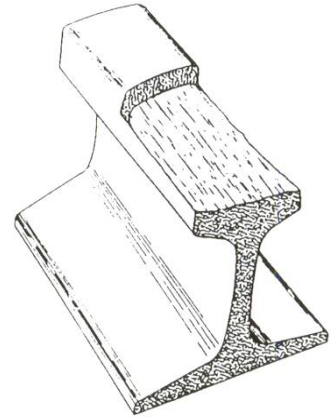
Internal seams, segregation or inclusions within the railhead cause horizontal split heads.

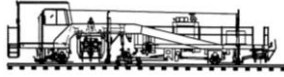
- The splits develop longitudinally (lengthwise in the rail) in a horizontal plane.



- 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.





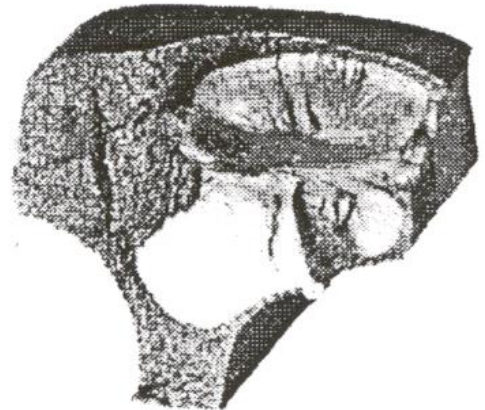
General appearance of a horizontal split head

In the second stage, a horizontal crack appears on either the gauge or field side of the railhead. These conditions are illustrated in Figure 16.

- 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 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:

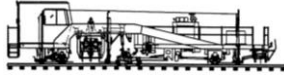
- 1) It tends to occur several places in the same rail, since the seam or segregation may exist throughout the rail length.
- 2) It may develop into a compound fissure, in which case service failure is a complete transverse break.



19. Vertical split head

MARTA Track Safety ,Standards definition for vertical split head

Vertical split head means 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.



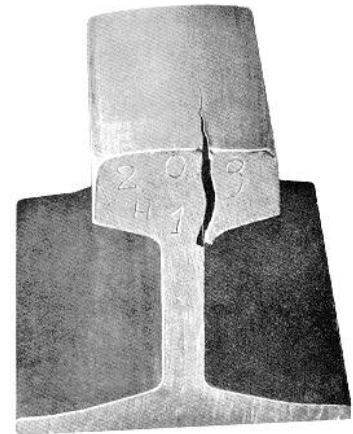
20. Development of vertical split head

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.

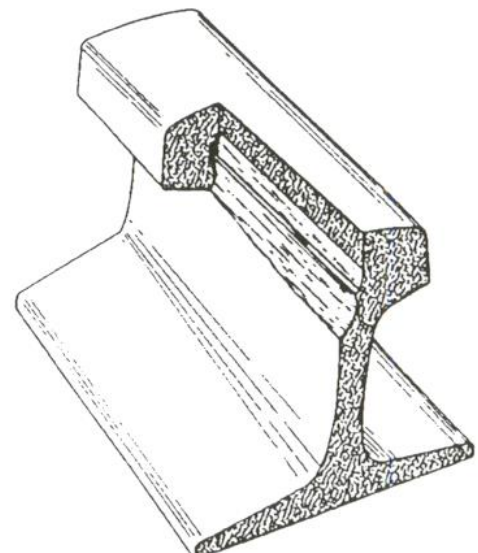
An experienced inspector can frequently detect a vertical split head in the rail.

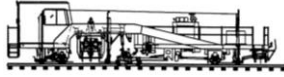
At times, widening of the railhead or sagging of one side of the railhead may be noted.

- 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.



- (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.





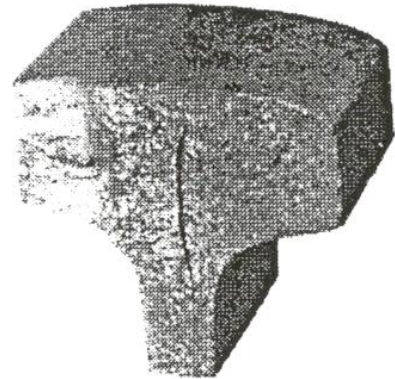
Vertical split heads usually grow to considerable size before such signs are visible. The length of these defects increases the likelihood of severe disintegration of the rail when a piece breaks out of the railhead.

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

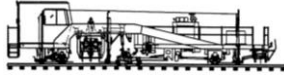
A web defect is any progressive fracture occurring in the web of the rail having, primarily, a longitudinal separation. These general classification of defects can be identified on the rail as follows:

- Piped rail
- Split web

1. Piped rail

MARTA Track Safety Standards definition for piped rail

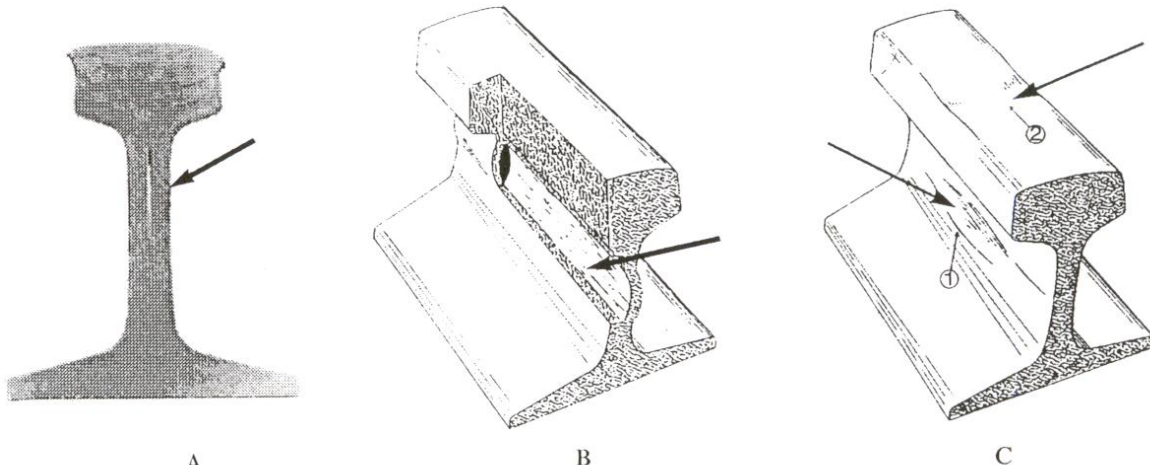
Piped rail means a vertical split in a rail, usually in the web, due to failure of the shrinkage cavity in the ingot to unite in rolling.



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.

2. 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.

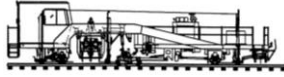
- This type of defect is seldom found in modern rail in an advanced stage.

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.



3. Split web

MARTA Track Safety Standards definition for split web

Split web means a lengthwise crack along the side of the web and extending into or through it.

4. 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.

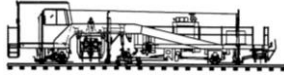
Web Defects in Joint Area

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





5. Bolt hole crack

MARTA Track Safety. Standards definition for bolt hole crack

Bolt hole crack means 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.

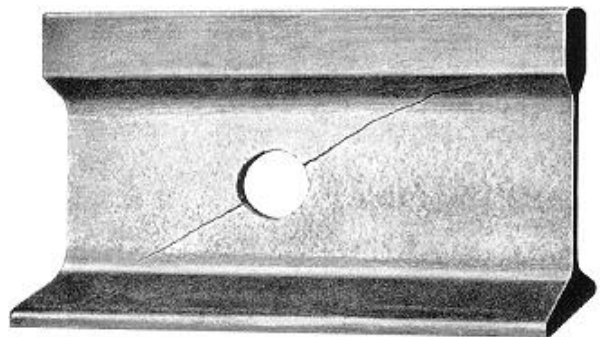
6. Development of bolt hole cracks

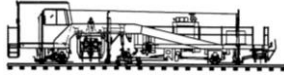
Bolt hole cracks are, of course, not visible until a bolt or the joint bar is removed, unless the defect has progressed above the joint bar and through the railhead or below the bar and through the base.

- 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.

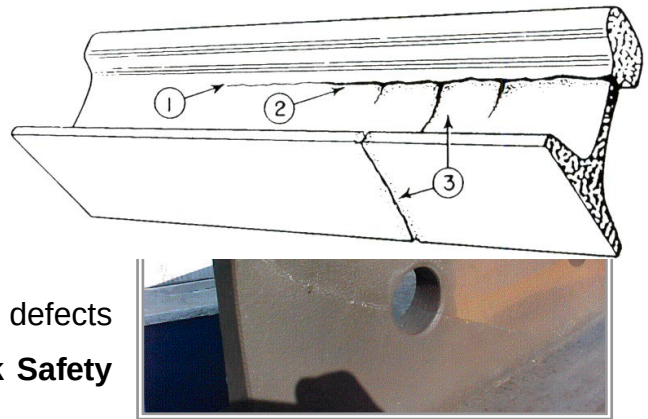




A bolt hole defect originates at a bolt hole and usually progresses at an angle. However, with current high axle loads and special rail steels bolt hole defects can be somewhat perpendicular out of the second and/or third bolt holes.

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. See the **MARTA Track Safety Standards** for required remedial action.



7. Head and web separation

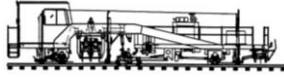
MARTA Track Safety Standards definition for head and web separation

Head web separation means 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) 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 extend downward
Characteristics of a head and web separation in track from the longitudinal separation through the web, and may extend through the base.

8. 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.

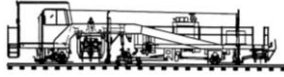
- The growth is also rapid once the rail had been turned, as this moves the loading point to the opposite side of the head with the joint bars.

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

1. Broken base

MARTA Track Safety Standards definition for broken base

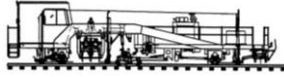
Broken base means any break in the base of the rail.

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.



Descriptions in the drawing

A crack starting near the junction of the base and web and extending outward to the edge of the base

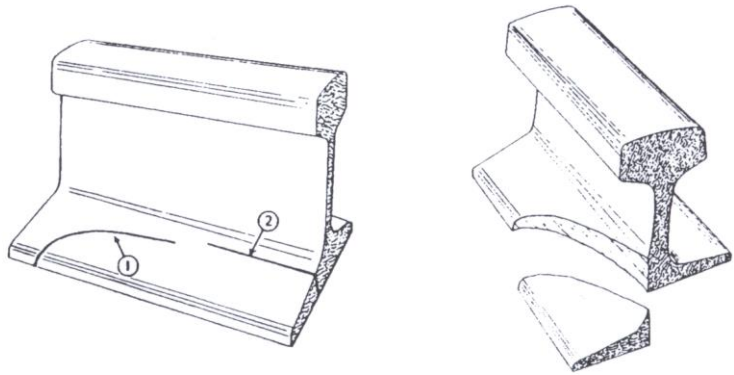
- 1) A longitudinal crack extending along the junction of the web and base
- 2) A half moon break in the base of the rail. General appearance of a broken base

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

2. 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.

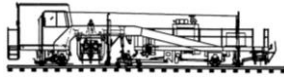


A nick or blow on the edge of the base that results in an indentation or step usually cause the base fractures.

- Improper rail handling sometimes causes damage of this nature.

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.



3. Damaged Rail

MARTA Track Safety Standards definition of damaged rail

Damaged rail means any rail broken or inferred by wrecks, broken, flat, or unbalanced wheels, slipping, or similar causes.

4. 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.

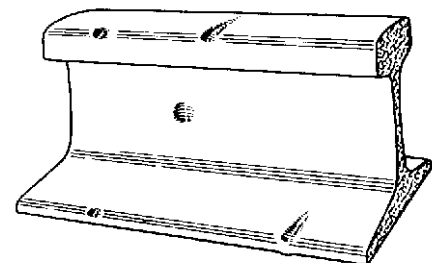
Another type of damage may produce kinking of the rail. Kinked rail is not considered to be serious from the standpoint of possible failure but continued use can create maintenance problems.

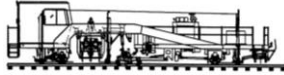
Another form of damage consists of nicks in the rail.

- 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

MARTA Track Safety ,Standards definition for defective weld

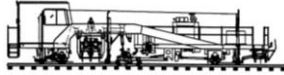
Defective weld means a field or plant (shop) weld containing any discontinuities or pockets, exceeding 5 percent of the rail head area individually or 10 percent in the aggregate, originated in or near the transverse plane, due to incomplete penetration of the weld metal between the rail ends, lack of fusion between weld and rail end metal, entrapment 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 end.



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.

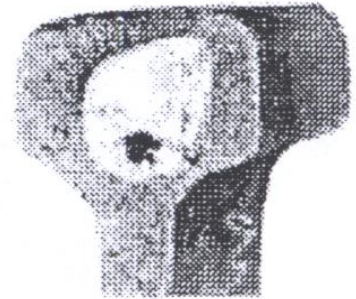
- The defect may be in the head, web, or base of the rail.



1. 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.

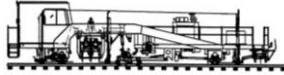
Ruptures of improperly fused welds or other gross weld imperfections will usually occur in handling or when initially exposed to traffic.

See the MARTA Track Safety Standards for required remedial action

2. Defective Field Weld

No outward sign is visible until the internal head defect reaches the rail surface.

- A vertical, bleeding hairline crack where the separation has reached the surface may then be recognized as a defective weld.

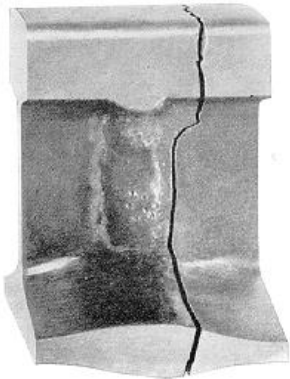


A longitudinal web defect, similar in appearance to a split web defect outside the joint or weld area, is usually visible as a bleeding hairline crack running lengthwise through the weld.

The fracture face usually shows a progressive transverse defect similar to a transverse fissure in the head of the rail. The core or focal point of the defect will reveal the cause of the defect. Inclusions or oxide entrapments are sometimes found in the base fillet or base flange areas.

The defective weld is dangerous because failure frequently occurs before the defect becomes visible or a service break is a complete break through the head, web and base.

- A longitudinal break across the rail web will sometimes cause a separation of a portion of the railhead.



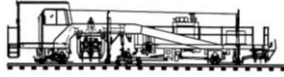
A defective field weld may be either a progressive fatigue fracture or an internal weld discontinuity that occurs as a result of improper weld materials or procedures.

- Defective field welds are caused by slag entrapments, inclusions, porosity or stress risers in the weld-upset area.

The fatigue failure will progress in a manner similar to a transverse fissure, usually in the railhead. Split webs through the weld area from slag, pipes or stress risers in the weld upset area may also occur.

- See the **MARTA Track Safety Standards** for required remedial action.

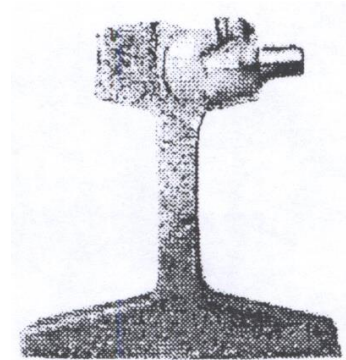
As in plant weld defects, no outward sign of a head defect is apparent until the internal defect reaches the rail surface.



- It is then visible as a vertical, bleeding crack.

When split webs are present in the mid web area, they are usually visible as bleeding hairline cracks running lengthwise through the weld, although, in some instances, the hairline crack is too tight to be readily apparent.

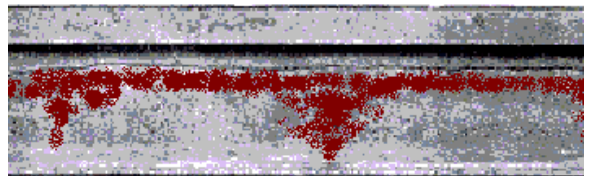
The fracture face may show typical transverse defect progression rings around an internal discontinuity or the fracture may occur from the internal weld discontinuity prior to the development of fatigue rings.



Progression of longitudinal cracks in the mid-web area is usually extremely rapid.

- A focal point for longitudinal web cracks at a weld can usually be identified within the weld area.

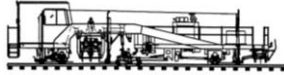
The defective weld is dangerous because failure from slag entrapments or other internal defects usually occurs before the defect is visible. Longitudinal web cracks that extend outside the weld area frequently cause a complete displacement of a portion of the railhead.



3. Detail Fracture From Welded Bond Wire Connection

The detail fracture from a welded bond wire connection is a progressive transverse defect that develops and expands from the point on the railhead where a head bond is attached by welding.

It is questionable whether the primary cause of detail fractures from welded bonds is due to thermal cracks being created by rapid or irregular cooling at or near the point where the bond is attached.



See the **MARTA Track Safety Standards** under detailed fracture for a welded bond wire connection required remedial action..

No sign of transverse defect is visible until the separation reached the rail surface and it cracks out.

- The defect can then be recognized by a hairline crack at right angles to the running surface near the point where a welded bond connection is or has been attached to the railhead.



The face of the rail shows a polished transverse defect with typical growth rings that have the appearance of gradually enlarging semi-circles with the center or focal point at a welded bond connection.

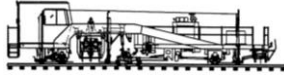
The detail fracture from a welded bond connection is a dangerous defect because:

- 1) Service failure results in a complete break through the head, web and base.
- 2) Growth is exceptionally rapid once the defect develops
- 3) Failure usually occurs before there is any external evidence that a defect is present.

4. Ordinary Break

MARTA Track Safety Standards definition of a ordinary break

Ordinary break means a partial or complete break in which there is no sign of a fissure, and in which none of the other defects described in this paragraph (b) are found.



5. Flattened Rail

MARTA Track Safety Standards definition for flattened rail

Flattened rail means a short length of rail, not at a joint, which has flattened out across the width of the railhead to a depth of 3/8 inch or more below the rest of the rail. Flattened rail occurrences have no repetitive regularity and thus do not include corrugations, and have no apparent localized cause such as a weld or engine burn. Their individual length is relatively short, as compared to a condition such as head flow on the low rail of curves.

6. Surface Defects

Rails are frequently subject to various forms of surface defects.

- Their presence does not indicate that the rail contains a dangerous defect.

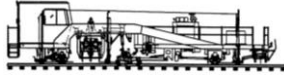
Occasionally, some of them can cause the development of internal defects such as the detail fracture or the engine burn fracture. A surface defect is any imperfection, damage, or deformation at or near the exterior surface of a rail.



This general classification includes defects which can be identified on the surface of the rail:

- | | |
|----------------|---------------------------|
| • Corrosion | • Head check |
| • Corrugation | • Flowed rail |
| • Crushed head | • mill defects |
| • Engine horn | • Shelling (Shelly spots) |
| • Flaking | • Slivers |

Internal defects developing from surface defects are reported according to the type of internal defect.



7. Corrosion

Corrosion is the eroding, rusting away, decaying or corroding of the metal on the web or base of the rail which results in irregular pits or cavities.

- It most often weakens the base of the rail particularly the outer edges.
- Sometimes the fillet, where the head and web are joined becomes weakened.



The corrosion is usually a slow process that occurs over an extended period of time. However, this process is greatly accelerated by electrolytic action on railroads where electricity is the primary means of motive power.

Corrosion can be recognized as pits or cavities on the upper base or web of the rail. Severest corrosion usually occurs underneath the base and is therefore not visible whenever the rail is in place.

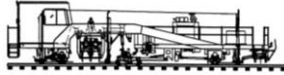
Example of base corrosion

Corrosion usually occurs in wet or damp areas such as tunnels or hi-rail accesses.

- It may be necessary to dig out a small section of the rail to determine if corrosion has developed.



Water can accumulate on both the rail base and the rail fastener under these conditions.



Corrosion is potentially dangerous because complete failure through the head, web and base usually occurs whenever the cross-sectional area of the rail section is sufficiently weakened by the corrosive action.

- Severe impact from flat wheels often causes ruptures when the rail has been previously weakened by corrosion.

Faces of the break will have the appearance of a sudden rupture with no progressive transverse defect development such as highly polished growth rings.

- Pits or cavities often one-half inch deep will be evident at failure locations.

H. Defective Rail Standard

Purpose of Defective Rail Standard

This completes the descriptions of the various types of defects. It is essential that the action, taken in the presence of any rail defect, will provide reasonable assurance of safety.

- Some types of defects are much more hazardous than others.

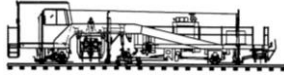
It is also necessary not to impose a greater degree of interference to rail traffic than is required in the interests of safety. For these reasons, the FRA specifies a different course of action for each type of defect.

MARTA has consolidated various courses of action into a **Remedial Action Table**.

- This table is very useful for ready reference on the job, once you learn how to use it.

It should be remembered, however, that it is not necessary to memorize the standard. When confronted with a defective rail in track





or any other track defect, Track personnel should always have a copy of the MARTA and FRA standards readily available for reference.

It is necessary however, to know in advance how to use the Remedial Action Table.

- This can be accomplished by carefully studying the explanations and constantly referring to the appropriate column on the Table.

You should do this until you fully understand everything on the Table and the notes that follow it. The Table will then be valuable to you for use on the job, when you are faced with a defective rail, and need to make decisions regarding it.

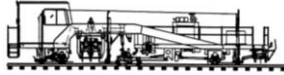
The remainder of this module will be devoted to developing an understanding of the proper use of the **MARTA Defective Rail Standard**.

1. Defective Rail Standard

Defective Rails

- (a) When an owner of track to which this part applies learns, through inspection or otherwise, that a rail in that track contains any of the defects listed in the following table, a person designated shall determine whether or not the track may continue in use. If he determines that the track may continue in use, operation over the defective rail is not permitted until
- (1) The rail is replaced: or
 - (2) The remedial action prescribed in the table is initiated.

See remedial action table in the MARTA Track Safety Standards.



How to Use the Remedial Action Table

At first glance, the Remedial Action Table may appear to be confusing, but it is fairly easy to correctly use once you understand how it is laid out. You need to know the type of rail defect and the length of the defect in inches or how much of the cross-sectional area of the railhead is weakened by the defect.

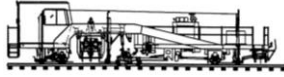
- First, find the ***name of the defect*** in the defect column.
- Look across to the ***Length of defect*** area, if the particular defect is to be measured in length (e.g. broken base).
- If the railhead area weakened by the defect is to be determined (e.g., transverse fissure) look further to the right to the percent of railhead cross-sectional area weakened by defect.

Once you find the applicable length or area, look to the right columns for the corresponding note for the prescribed remedial action.

1. On a mainline track with a maximum operating speed of 60 mph, you find a rail with a vertical split head on the gauge side of the rail head. On the Remedial Action Table, look up vertical split head, then look for the vertical split – gauge side. Since the remedial action for a vertical split head on the gauge side is different from a vertical split head on the field side the action for each may be different. Now read the next column to the right to see that Remedial Action “A” is required.

NOTE: A. If it is determined by a Qualified Person to continue train operations, the person making the decision must not leave the scene until the condition is protected, they are relieved or until the defect is repaired.

- When, in the judgment of a Qualified Person, that it is safe to do so, **“Walking”** trains over such a condition is allowed.
- Limit operating speed over defective rail to that as authorized by a Qualified person who shall have at least:



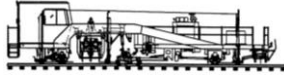
- (i) One year of Track Supervisory experience, or
 - (ii) Been Qualified as a Track Walker, or
 - (iii) Two years' experience in Track Maintenance
- Each train shall be stopped short of the defect and a Qualified Person on the ground shall communicate the situation to the train operator. Movements shall be made at **“Restricted Speed with Extreme Caution”**; that is, proceeding no faster than 5 to 10 mph dependent upon conditions.
 - The Qualified Person on the ground will constantly monitor the movement of each train over the defect and be prepared to stop the train at any time that it is determined to be unsafe to continue.

Action: You must put into effect a slow order reducing speeds for all trains. **Restricted Speed with Extreme Caution** to a maximum of 5 to 10 mph for the entire length of train over that defect and then constantly monitor the movement of each train over the defect and be prepared to stop the train at any time that it is determined to be unsafe to continue.

NOTE: Replacement of the defective rail is “Required”. Applying joint bars is not Allowed.

2. **Lets try another problem.** On your 60 mph mainline you discover a rail with a Bolt Hole Crack that you determine is 4 inches long. If you do not replace the rail immediately, you would follow the remedial action in the following Note.

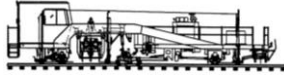
NOTE: From the Remedial Action Table. **E.** Apply joint bars to defect and bolt in accordance with MARTA Rail Joint Standards
F. Limit operating speed over defective rail to 30 m.p.h. or the maximum allowable speed for the class of track concerned, whichever is lower.



The 30 mph or less as authorized by a Qualified person as designated in the MARTA Track Safety Standards, who has at least:

- One year of Track Supervisory experience, or
- Been Qualified as a Track Walker, or
- Two years' experience in Track Maintenance

Action: This means you would slow order the track for all trains to a maximum of 30 mph or less. Apply joint bars to the defect bolting through the two outermost holes only.



Glossary of Terms

Rail Defects

Bleeding - Reddish-brown streak indicating internal rusting,

Cant - To lean or tilt an object, such as a rail, slightly from level. Cant is usually expressed as a rate of inclination, such as 1 in 40, etc.

Chamfer - A flat surface made by cutting off the edge or corner. It may also be a groove or furrow.

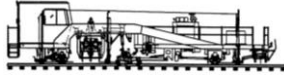
Compound fissure - A progressive fracture in the head of the rail generally starting as a horizontal separation which turns up or down, or in both directions, to form a transverse separation substantially at right angles to the running surface.

Creped - A wrinkled surface.

Detail fracture from head check - A progressive fracture starting at the gauge corner of the railhead and spreading transversely through the head.

Detail fracture from shelling - The detail fracture 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 at right angles to the running surface.

Detected defects - Defective rail detected by detector equipment or visual means.



Engine burn fracture - A progressive fracture in the head of the rail, starting from a burn, with transverse separation substantially at right angles to the running surface.

Engine burns - Are surface defects consisting to damage of the rail tread. They are caused when considerable heat is generated between the wheel and the rail. Metal is removed From the top of the rail causing depressions also known as wheel burns.

Entrainment - To pull or draw along after itself.

Field side - Side of railhead away from wheel flange.

Flash butt weld - An electric pressure weld.

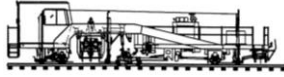
Flattened rail head - A depression of the railhead that is across the width of the railhead. YN inch deep at the deepest point and 8 inches in length. Occurrences have no repetitive regularity, however, do not include corrugations or railhead conditions associated with a driver burn or weld.

Flowed rail - A rail flaw consisting of the rolling out of the rail tread metal past the corner of the railhead. Flow occurs from repeated loads to the rail.

Gauge side - Side of railhead closest to wheel Mange.

Head checks - Transverse surface cracks on the gauge corner of rails resulting from cold working of surface metal. These are sometimes referred to as gauge cracks.

Heat - One loading, or charge, of metal from a furnace at the steel mill. All rails rolled from the ingots from one heat arc said to be of the same heat.



Horizontal split head - Is a progressive longitudinal fracture in the head of the rail, usually 1/4 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 with the rail when it reaches the side of the railhead.

Inclusion - Small quantity of gas or slag that is trapped in molten steel and remains in after cooling.

Nucleus - Origin, starting point, or kernel or defective growth in some defects.

Ordinary break - A service rail failure that shows no apparent inclusion or defect progression.

Oxide entrapment - An oxide is a binary compound of an element or radical with oxygen.

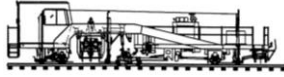
Percent size - Percentage of railhead cross-sectional area that is weakened by defect (transverse defect only).

Rail failure - Broken rail resulting from service or environmental conditions.

Re-laid rail - Worn but still usable rail taken from track and reused in another location.

Reverse detail fracture - Is a progressive fracture starting at either bottom corner of the railhead, spreading transversely through the head.

Sands Mirror - An angled inspection mirror with a handle that allows the visual inspection of the side of the railhead and head fillet radius as an inspector walks.



Shatter crack - Minute crack in steel, caused by rapid or uneven cooling of rail during manufacture.

Shell (Shelling) - The *Rail Flow* consisting of shell-like flakes of steel that have come off the *Railhead*. *Shells* are Generally shallow. inch or less in depth, and occur where excessive pressure is exerted on the railhead. Very shallow shells are called Spalls.

Slag - A non-metallic Fused product resulting from the reduction of ores in furnaces.

Transposed rail - Rail that is moved from one side of the track to the other side, without turning the rail, so that gauge and field sides are reversed.

Transverse fissure - A progressive crosswise fracture starting from a center or nucleus inside the head of the rail, then spreading outward substantially at right angles to the running surface of the rail. The internal nucleus is an imperfection in the steel, such as a shatter crack, or a minute inclusion or blowhole. Impact of the wheels and bending stresses start the growth of a transverse separation around the imperfection.

Tread - A portion of the wheel contacting the running surface of rail.

Turned rail - Rail with some wear that has been removed, turned end for end and placed back in track, so that gauge and field sides become reversed.

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.