A Standard Of Excellence

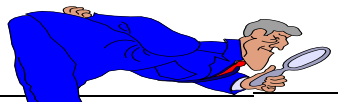
Technical Training

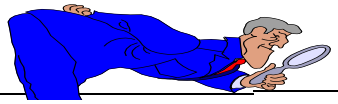
Track & Structures

Track Inspection Training

Rail Defects

Section 7





RAIL DEFECTS

MARTA's running rail is standard AREA 115RE section. This rail must be inspected daily in conjunction with the regular walking semi-weekly Track Inspection.

- Any and all rail defects must be noted in the Track Inspection Report.

All visible cracks, which extend beneath the surface of the rail, should be reported immediately to track and Structures Maintenance Supervisory personnel ASAP and the operating speed reduced to 10 M.P.H.

- In addition, the inspector must flag all trains through the defect area.

Upon arrival, supervisory personnel must decide if;

1. The slow order should remain in effect
2. If normal operations should be restored
3. If joint bars should be applied to the defective area
4. If the track should be removed from service until the defective rail can be replaced
5. Any combination of the above.

Supervisory personnel should oversee the conduct of an internal ultrasonic rail defect test if there is any question concerning the rails structural stability.

Listed below are some of the common rail defects, which should be noted in the Track Inspection Report.

Track Safety Standards - Inspection of Rail.

(a) In addition to the track inspections required, a continuous search for internal detects shall be made of all rail in Classes 4 through 5 track, and Class 3 track over which passenger trains operate, at least once every 40 million gross tons (mgt) or once a year; whichever interval is shorter: On Class 3 track over which passenger trains do not operate such a search shall be made at least once every 30 mgt or once a year; whichever interval is longer:

(b) Inspection equipment shall be capable of detecting defects between joint bars, in the area enclosed by joint bars.

(c) Each defective rail shall be marked with a highly visible marking on both sides of the web arid base.

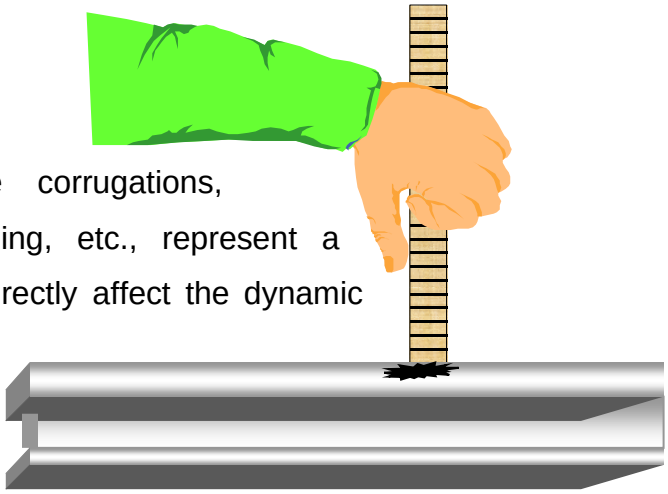
(d) If the person assigned to operate the rail defect detection equipment being used determines that, due to rail surface conditions, a valid search for internal defects could not be made over a particular length of track, the test on that particular length of track cannot be considered as a search for internal detects under paragraph (a) of this section

(e) *If a valid search for internal defects cannot be conducted for reasons described in paragraph (d) of this section, the track owner shall, before the expiration of time or tonnage limits -*

(l) Conduct a valid search for internal defects;

(2) Reduce operating speed to a maximum of 25 miles per hour until such time as a valid search for internal defects can be made; or

(3) Remove the rail from service.



A. Running Surface

Rail surface defects, which include corrugations, corrosion, engine burns, surface spalling, etc., represent a significant class of rail anomalies that directly affect the dynamic wheel/rail behavior.

In categorizing and defining rail surface defects, the primary characteristics are:

- Defect depth; usually in 1/1000 of an inch. This is the value between the top of the rail surface and the bottom of the defect.
- Defect wavelength; for periodic defects, such as corrugations. Defined as the distance between adjacent wave peaks (or valleys) and given in inches.

Rail Surface Condition Measurement Tools.

The following tools are recommended for the rail surface condition inspection

All tools must be used with extreme care to avoid bridging insulated joints and contact with energized third rail.

Straight-edge and Taper Gauge

- On conventional joints, one edge of the straight edge is placed at the joint, then using the taper gauge, the batter is determined.
- Rail corrugations can be measured using these tools.



Note: The straight edge and taper gauge is of little or no value in measuring engine burns and other similar flaws in the rail surface.

Dial Indicator and 36 inch Straight-edge

- The 36 inch straight-edge is used as a bridging device. The dial gauges also have an accuracy to +/-0.003 inches.
- Dial Indicator and Parallel 36 inch Straight-edge
- Used for measuring defects that extend over longer distances. The dial indicator can be moved anywhere along the 36 inch length of the straight edges, and can obtain continuous measurements along the length.

Rail Head

Most new rails are installed in main tracks with heavy traffic. Usually, several hundred million tons of traffic will pass over these rails before they are replaced.

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

- Rail weld defects usually progress from inclusions or slag entrapments at the weld interlace.

- Some longitudinal weld defects in the mid-web area may result from residual stresses in the weld area or stress risers resulting from improper removal of upset metal.

Inspection of standard rail begins on the manufacturing line. This inspection includes a preliminary inspection before straightening, grinding, drilling, etc.

The purpose of the preliminary inspection is to check identification and lengths and to detect harmful surface defects that would eventually cause the rail to be rejected.



After preliminary inspection, the rails are cold straightened in presses or mechanical roller straighteners.

- Residual burrs are removed from the rail ends and the rail ends are chamfered, beveled and drilled if required depending upon the intended eventual use for the rail, i.e., bolted rail or continuous welded-rail.
- All rails are closely inspected for straightness and other physical dimensions.

The **AREMA (American Railway Engineering and Maintenance-of-Way Association)** per the revised specifications effective in August 1988 requires ultrasonic inspection of rails in the manufacturing line.

The inspection of rails must be made for internal imperfections unless it has been agreed between the purchaser and the manufacturer that a manual ultrasonic inspection of the area within 12 inches of the rail end may be used in lieu of the in line inspection.

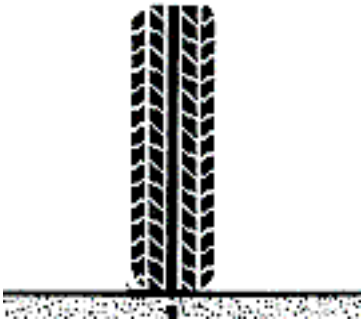
- These test standards are not addressed in this lesson; they are defined in **AREMA's Specification for Steel Rails**.

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

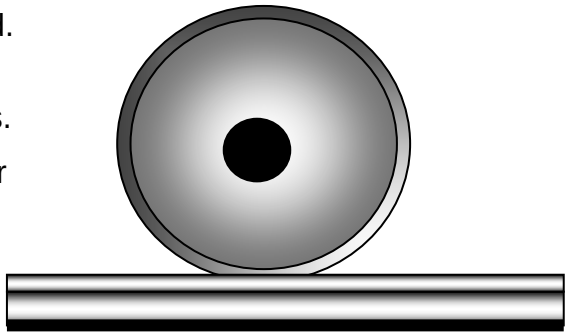
- This capability has led to substantial increases in the weight placed upon each wheel.
- Some of the larger increases have occurred in recent years with 286,000-pound railcars becoming more common.

One of the characteristics of the wheel-to-rail combination is the lack of deformation under load, such as happens with the rubber tire upon a road.

- This quality of steel is essential to the small amount of friction developed in the movement of rail equipment.
- It results, however, in very concentrated loads being placed upon both rail and wheel at the point of contact.



In this module, some of the things that happen to rail as a result of these wheel loads will be examined.



Defective rails may be discovered in various ways. At its worst, a rail that fails in service is found after it has caused a derailment.
In other cases, it may be located because it broke through and caused a signal failure.

Train operators who either see a broken rail or hear the wheels of their train pounding on the break find some service failures.

- Others are located by track inspection before interruptions to rail traffic can occur.

Development of Defects

The growth of a rail defect depends on a great many variables.

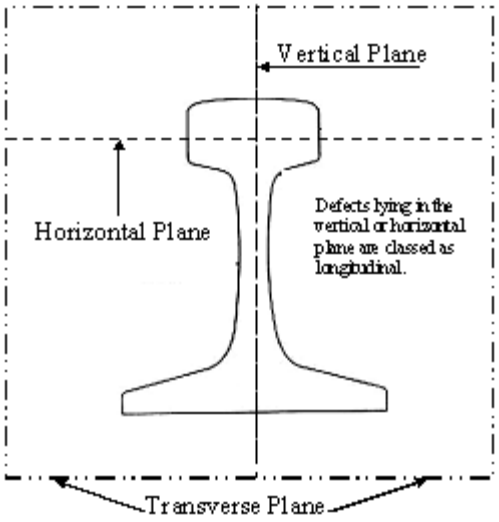
- The chemical composition of the rail and the amount of rail flexing are factors, which must be considered.

The type of rolling stock (freight, passenger, or motive power), its weight, and its condition of repair are important, as well as the frequency of these loads.

The condition of the roadbed and weather changes which result in track movement also affect growth. With so many variables contributing to development, it is impossible to predict accurately the growth of any defect.

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

Internal defects actually experience a growth in size, although the type of growth cannot be classified, nor the defect size measured (except by hand testing) until the rail is broken to show the face of the defect.



B. Visual defects

External defects are not always easily detectable unless they have resulted in an obvious break in the rail or a breakout of a piece of rail from the running surface.

Visual inspection is sometimes aided by a mirror to check under the head of the rail and discover the more obvious defects such as, vertical split heads and half-moon base breaks.

However, this type of inspection cannot detect those internal separations of the steel on the railhead known as a transverse defect, and frequently overlooks horizontal split heads.

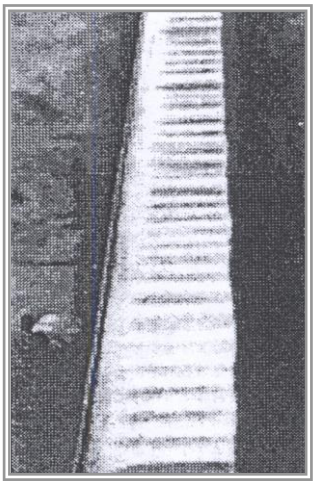
- Some rails contain irregularities that are apparent to a trained inspector, even though the rail has not yet failed.
- Some of the conditions are considered to be defects because under continued service they will lead to failure.

Railhead Surface Defects

Corrugation

Corrugation, sometimes called washboard rail, is a series of waves or variations in top of the railhead which are more or less accentuated and irregular.

- The short wave or rail length of the corruption usually varies from two to three inches.



Intermediate wave corrugation or undulations at times could exceed 10 to 12 inches in length.

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

The very long wave corrugations have a wavelength greater than 24 inches and are common on very high-speed operations. Furthermore, this type of corrugation has a very shallow depth between peaks.

Corrugations have the appearance of regular bright and dark streaks across the running surface of the rail.

Corrugation is caused by uneven rail wear.

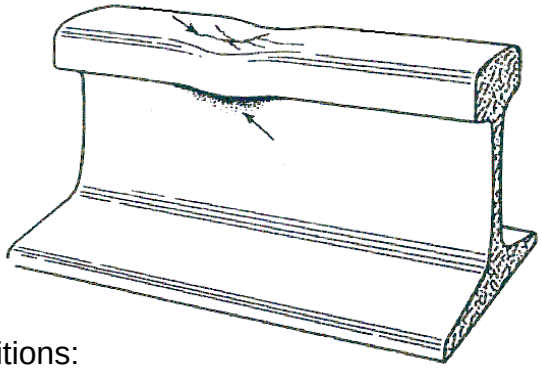
- It is generally attributed to a repetitious wheel sliding action of some nature whether through heavy braking or lateral motion across the rail surface.
- It is not considered to be a serious defect but is usually removed from high-speed track because of the rough ride it causes.

Crushed head

Crushed head is a rail flaw caused by flattening or drooping of several inches of the railhead.

- It is usually accompanied by a crushing down of the metal but with no signs of cracking under the head.

The crushed head usually originates by a soft spot in the steel of the head, which gives way under heavy wheel loads.



- The continual passage of the heavy wheel loads causes it to grow. Also higher train speeds and increasing depth of the flat spot accelerate growth.

Crushed rail can be identified by the following conditions:

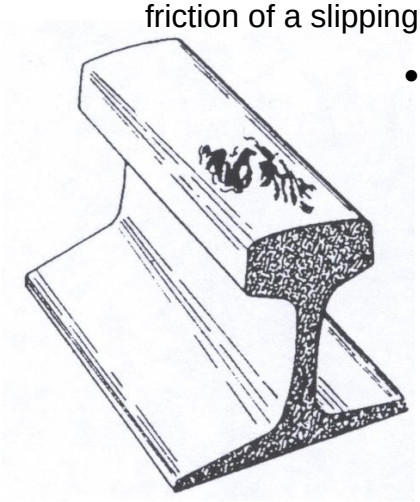
1) A flattening and widening of the head for several inches, with the entire head sagging.
2) Small cracks in the depression on the running service.
3) In advanced stages, crepe (wrinkled) surface or a bleeding crack at the fillet under the head

The crushed head is not a serious defect, but it is generally removed from high speed track because:

It causes rough riding of rolling stock. Points of concentrated loading may develop defects.

Engine burn or burned rail

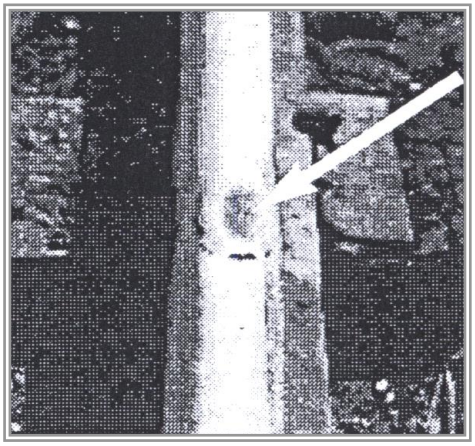
Engine burn is a defect consisting of damage to the rail tread caused by the high friction of a slipping locomotive wheel.



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

The presence of an engine burn in the track can also present other maintenance problems. The irregularity on the running surface of the rail creates an impact stress each time a wheel passes over it. This can produce increased deterioration of the supporting ties.

Many small engine burns remain in the track for long periods of time because they are not large enough to create pounding of an appreciable amount. Others have the irregularity minimized by grinding off upset metal, which has been displaced or disturbed by some other action.



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

Flaking

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

- It is a progressive horizontal separation on the running surface of the rail near the gauge corner, with scaling or chipping of small slivers.

Flaking should not be confused with shelling, as the flaking takes place only on the running surface near the gauge corner of the rail and is not as deep as shelling.

- It usually occurs on the high rail of curves.

While flaking is not considered to be a serious defect, it sometimes develops into shelling.

Flaking originates at the surface of the rail. It is prevalent on the high side of curves, switch points. and locations where concentrated loading on the tread and gauge corner cold works the steel.

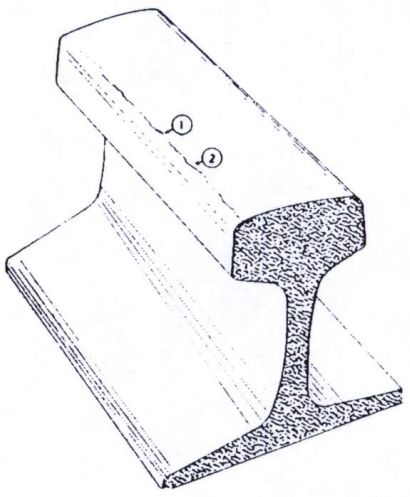
The growth depends on the loading. The separation progresses about 1/32 inch below the running surface toward the gauge side of the head, usually coming to the surface close to that point where the tread contour turns downward at the gauge side.

1) Very shallow depressions with irregular edges occur on the running surface near the upper gauge corner. They generally will not occur more than one fourth inch from the gauge corner of the rail.
2) Horizontal cracks along the running surface near the upper gauge corner of the railhead resemble small slivers.

Head check

A head check is a rail defect consisting of shallow surface or hairline cracks, which appear in the gauge corner of the railhead.

- They appear at any angle with the width of the rail.



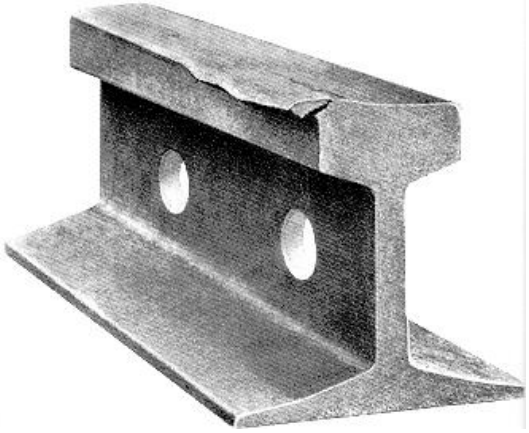
Head checks generally run at a 45-decree angle to the axis of the rail: they usually occur on the high rail of curves. Concentrated wheel loading at the gauge corner of the railhead causes them. Detail fractures can originate from head checks.



Flowed rail

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

- Flowed rail is not a serious defect.



Flow is due to distortion of the rail metal under repeated loads. This gradual change of the head contour does not damage the metallic structure of the metal.

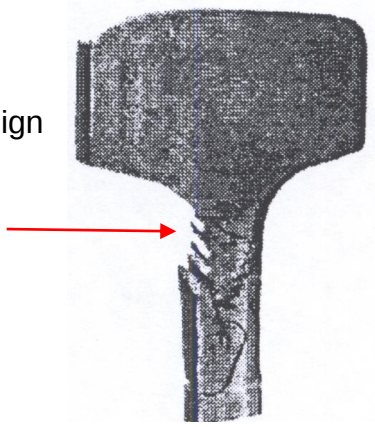
Flowed rail is a change in shape rather than a growth. It occurs, predominately in curved track, under repeated service. The extent of the change is usually proportionate to the length of service of the rail.

- Rail in tangent track may also become flowed, although at a slower rate than in curved track.

Appearance of flow in rail as shown in the photo, shows this section of rail with head flowed to field side, some of lip cracked or broken off.

1) Surface metal on the head flowed on the field side, giving a creased appearance on the running surface near the field.
2) A smooth protruding lip (which may extend the length of the rail)
3) In advanced stage, flow becomes like a blade, jagged, or non-uniform, and may hang down or separate from the railhead.

Mill defects



Mill defects are deformations, cavities, seams. or foreign material found in the head, web or base of a rail.

- They occur when the ingot is poured.
- Slag, gas, or foreign material may be included.

Metal that splashes on the side of an ingot mold may cool and oxidize to some extent before fusing with the liquid metal. Although the defect does not actually grow, it may furnish the point of origin for a transverse or longitudinal separation. Further development depends on the type of mill defect, its location in the rail, and loading of the rail.

Production factors that contribute to the manufacture of inferior rails have been minimized through refinement in rail mill practice, but invisible internal defects still occur in the latest types of rail.

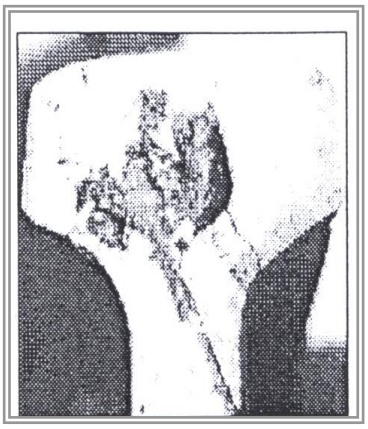
- Currently many rails remain that were rolled prior to the development of the more modern rail production techniques.

Conditions caused by mill defects:

1) A deformation of the railhead which can cause passing car wheels to batter the rail severely
2) Broken out inclusions leaving large or dangerous cavities in the side or running surface of the railhead.

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

Shelling (shelly spots)



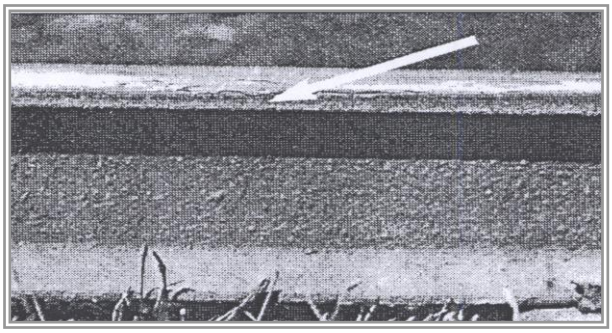
Shelling, sometimes called Shelly spots, is a rail defect consisting of shell-like flakes of steel that have come off the railhead. It is a progressive horizontal separation that may crack out at any level on the gauge side, generally at the upper gauge corner.

It extends longitudinally, not as a true horizontal or vertical crack, but at an angle related to the amount of rail wear. Very shallow shells are called spalls. Also, in the case of a small shell there may be no surface evidence.

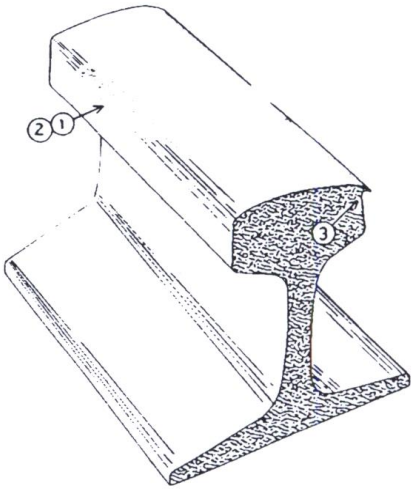
The existence of the shell maybe apparent only after the railhead is broken or sectioned.

The exact origin of shelling has not been definitely determined.

Shelling is prevalent at curves and where excessive pressure is exerted on the railhead. It is accelerated if streaks or small seams are present and provide stress concentration points. Uncapped shell often shows these characteristics of origin. The growth depends on the loading. The separation progresses in the path of least resistance. Shelling may turn down to form a transverse separation, in which case the defect would be classified as a detail fracture from shelling.



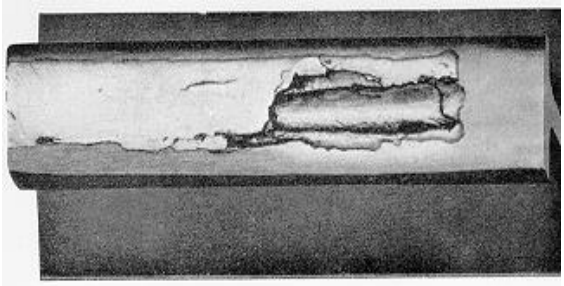
1) Dark spots are irregularly spaced on the gauge side of the running surface.
2) Longitudinal separation occurs at one or several levels in the upper gauge corner, with discoloration from bleeding.
3) If rail is turned, shelling will appear on the field side, with an irregular overhanging lip of metal. Appearance is then similar to flowed metal.



Shelling is potentially dangerous because it occurs most frequently in curve territory and transverse separation may develop at any stage of shelling or at any point along the shell.

Slivers

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

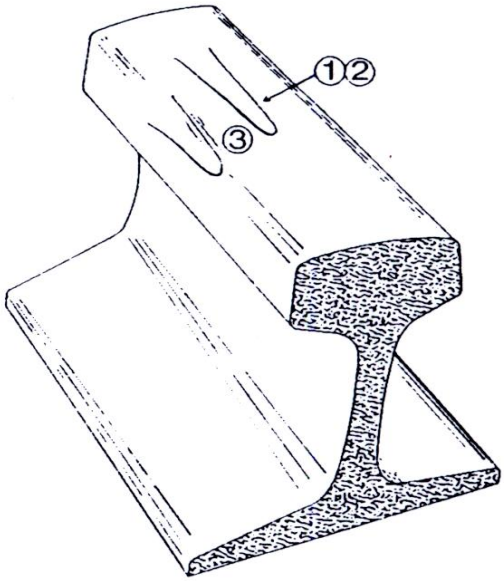


Slivers occur from an imperfection during the rolling process, when a small pre-oxidized section of rail laps over instead of flowing and welding under pressure of' the rollers.

Slivers separate rather than grow, but may chip off, cause batter, or furnish a point of origin for a transverse or longitudinal separation.

- They are not a serious defect.

1) Thin slivers (similar to wood slivers) are on the Surface of the railhead and parallel to the rail length.
2) Darkened slivers are shown (in advanced stage) giving an appearance much like the vertical split head but without any spreading or crushing of the railhead.
3) Slivers on the side of the railhead. Such slivers may be both shorter and thicker than slivers on the running surface. All slivers are generally less than 1/8 inch thick. They form part of the rail contour, lying flat on a surface, but may be cracked loose from rail metal on three sides. If a sliver has been dislodged, only an indentation will remain on the rail surface.



D. Internal Defects

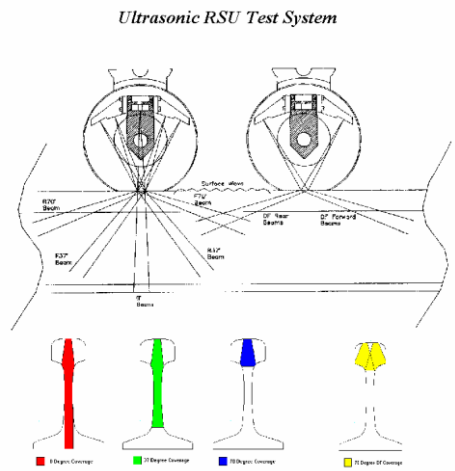
The other general classification is that of internal defects which the use of special inspection equipment.

- It may consist of a small device that is used when inspecting on foot.
- Other types involve on-track or hi-rail equipment.



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

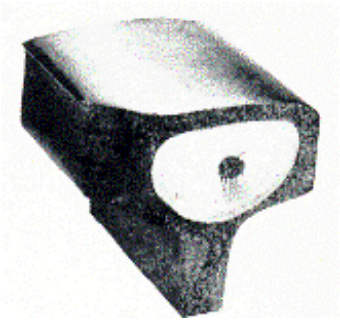
- The most widely used type of equipment is the **Sperry Car** which is operated by Sperry Rail Services to inspect the rail for such things as corrugation, engine burns, high & low welds and other rail defects.



Sperry equipment locates defects that are similar to those that result in many service failures. Frequently, the detection equipment locates defects that are entirely internal. Internal defects can usually be accurately classified without breaking the rail.

Each of the commonly recognized types of rail failures will be described and discussed. The definitions used are those of the **MARTA Track Safety Standards**

Transverse Defects in the Railhead



A transverse defect is any one of a group of defects with progressive fractures that occur in the head of the rail and has a transverse separation, of at least 5% of the cross sectional area.

- This general classification is made when the defect is found in the track.

If the rail is broken for examination, the transverse defect could be accurately identified as one of the following:

Compound fissure
Reverse detail fracture
Detail fracture
Engine burn fracture
Detail fracture from head check

Weld burn fracture

Detail fracture from shelling

Transverse fissure

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

The growth of the defect within the railhead may be very slow when the defect is small or quite rapid when the defect is large.

- Other transverse defects, which are still found in rails in significant numbers, are detail fractures, engine burn fractures, and occasional compound fractures.

Progressive transverse defects will also develop underneath engine burns or rail welds that have been resurfaced by welding when the area being rebuilt is not properly cleaned or cooled during the process.

A crack at right angles to the running surface. This is usually on the field or gauge side of the head, or at the fillet under the head, occasionally on the running surface.

Discoloration (red or purple oxidation) around the crack.

- This is called bleeding and is caused by internal rusting.

A crack at upper gauge corner of the railhead.

- On turned rail, this condition may occur at the field corner.

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

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

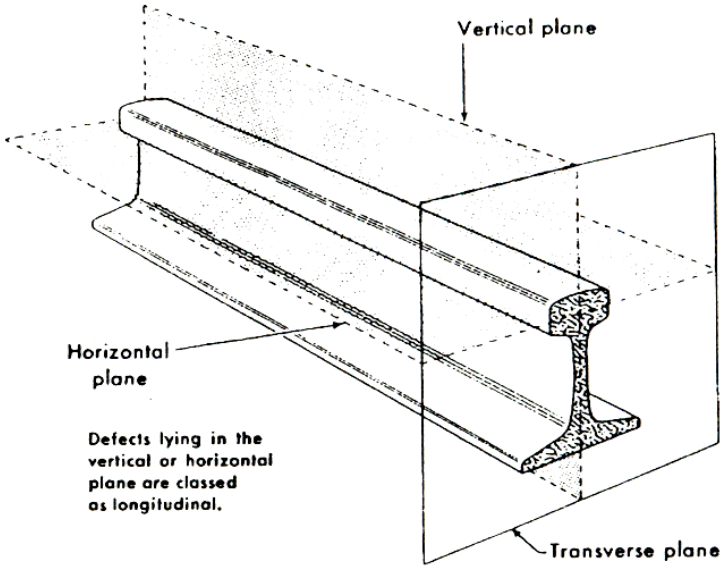
- Under such conditions a flat spot will generally be present on the running surface.

A crack extending downward at tight angles from a horizontal crack caused by shelling of the upper gauge corner of the railhead.

- Shelling can be identified by the presence of a slight discoloration on the gauge side of the running surface. On turned rail, the shelling area may be found at the field side.

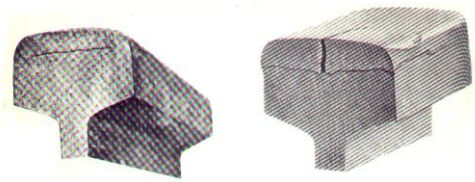
Compound fissure

Is a progressive fracture originating in a *horizontal split head which turns up or down) in the head of the rail as a smooth, bright, or dark surface progressing until substantially at a right angle to the length of the rail.*



Compound fissures require examination of both faces of the fracture to locate the horizontal split head, from which they originate.

Development of compound fissures



An internal longitudinal seam, segregation, or inclusion with the railhead starts the development of a horizontal split head.

- This horizontal separation, at times, may be very short, as little as 1/8 inch in length.

  The essential condition for a defect to be classified as a compound fissure is that there is both horizontal and vertical separation.
- Also, unlike the transverse fissure, there is no nucleus within the defect.



Compound fissures are dangerous for reasons similar to those that apply to the transverse fissure.

(a) They can occur at several locations in the same rail.

(b) In some cases, there is no visible defect until the rail actually breaks.

(c) When the rail breaks, it is usually a complete transverse break across the entire rail.

Detail fracture

Is a progressive fracture originating at or near the surface of the railhead. These fractures should not be confused with transverse fissures, or other defects, which have internal origins. Detail fractures may arise from Shelly Spots head checks, or flaking.

Development of detail fracture

Detail fractures have a transverse growth that may appear to resemble that of the transverse fissure. There are two differences.

1) The defect does not contain a nucleus in the case of the transverse fissure. The detail fracture originates at or near the surface.
2) The transverse fissure originates at an internal nucleus. Shelly spots. Head checks and flaking will be discussed later in this module in the section on surface defects.

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

Detail fracture from head check



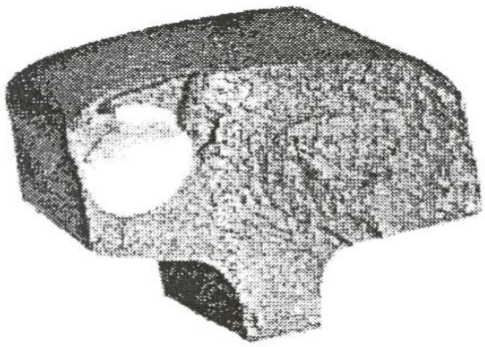
The detail fracture from head check is a progressive fracture starting at the gauge corner of the railhead and spreading transversely through the head. It originates in the upper gauge corner of the rail, usually

caused by the weight of concentrated loading which deforms the railhead. The detail fracture from head check is a dangerous defect because:

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

Detail fracture from shelling

The detail fracture from shelling, whether visible or internal, is a progressive fracture starting from a longitudinal separation close to the running surface of the railhead, then turning downward to form a transverse separation substantially at right angles to the running surface.



It usually originates from a longitudinal seam or streak near the running surface on the gauge side (field side if the rail has been turned or transposed).
The separation progresses longitudinally, not as a true horizontal or vertical crack, but at an angle related to the amount of rail wear on the gauge corner.

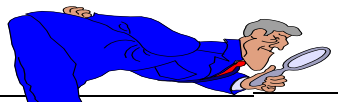
After some distance, the crack turns downward and inward to form a transverse separation.

- Positive identification cannot be made until the rail is broken

Identification after the rail is broken

The longitudinal separation and the streak or seam in which it originated is not always exposed. The transverse component resembles that found in a transverse fissure except that:

- No nucleus is present in the transverse separation.
- The transverse separation always spreads from a longitudinal separation in the upper gauge corner.



The detail fracture from shelling is a dangerous defect because:

- Growth may be rapid or sudden.
- Failure frequently occurs before the defect becomes visible.
- Service failure is a complete break of the rail across head, web and base.

Reverse detail fracture

The reverse detail fracture is a progressive fracture starting at either bottom corner of the railhead, spreading transversely through the head.

- The origin is a stress riser on the cold rolled lip on the bottom corner (gauge side or field side of transposed or turned rail) of the railhead and typically associated with severely worn rail and high axle loading.

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

- A positive identification cannot be made until the rail is broken.

The specimen exposes a transverse separation, which starts at the lower gauge corner and spreads in crescent-shaped rings radiating from the point of origin.

Reverse detail fracture the reverse detail fracture is a dangerous defect because:

- It can occur in several places in the same rail.
- It can fail completely below a 15 percent size.
- Failure typically occurs at 80 percent of the speed at the time of a typical detail fracture.
- Service failure is a complete break of the rail across head, web and base.