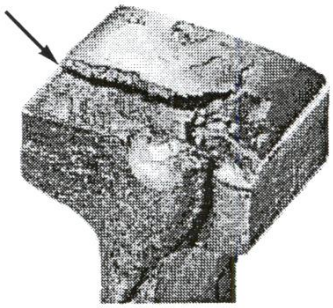
Engine Burn Fracture

Is a progressive fracture originating in spots where driving wheels have slipped on top of the railhead. In developing downward, they frequently resemble the compound or even transverse fissure with which they should not be confused or classified.

Development of Engine Burn Fracture



Many surface defects on the railhead similar in appearance to the rail surface remain in track for long periods of time without developing internal defects.

- The existence of such a surface defect does not necessarily mean that the affected rail should be replaced.
- The proper treatment of rails with engine burns caused by slipping driving wheels will be discussed in succeeding modules.

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

These defects may be minor, or severe enough to require verse separation immediate replacement of the affected rails.

The slippage causes rapid heating of the rail close to the surface of the railhead.

- Cooling may also be quite rapid.

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

- This causes pounding as each wheel moves over the burn.

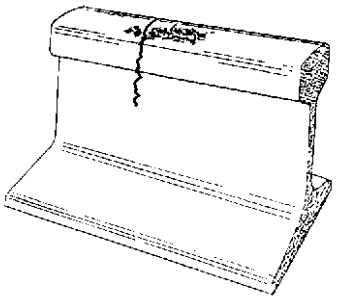
This combination of circumstances can cause growth of the horizontal separation, which can turn downward and form a transverse separation.

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

Appearance in Track - No sign of a transverse separation is visible until the defect reaches the rail surface (cracks out). An engine burn fracture may then be recognized by one or more of the following characteristics identified in the reference material listed below.

Gauge Side

1) A hairline crack on the side of the head, in the immediate vicinity of an engine burn on the surface, and at right angles to the running surface. The crack may be visible on either the field or gauge side of the head.



2) Transverse thermal cracks extending from the burn to the gauge corner and down the gauge side of the head as transverse components for at least 1/8 inch.

Field Side

3) A cracked out horizontal separation visible on the field side of the railhead under the burned area, accompanied by one or more thermal cracks which extend transversely to the gauge corner.

Welded Burn Fracture

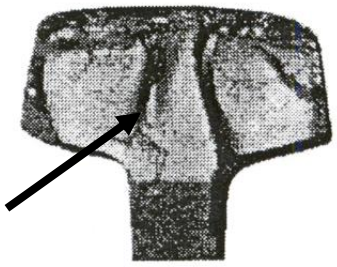
The welded burn fracture is a progressive transverse separation in the head of the rail, which develops substantially at right angles to the running surface at an engine burn, which has been resurfaced by welding.

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

Improper cooling of a resurfaced burn can also create new thermal cracks.

- No sign of a transverse separation is visible until the defect reaches the rail surface (cracks out).

A welded burn fracture can then be recognized by a crack at right angles to the running surface. The crack may be visible on the field or gauge side of the railhead or underneath the head in the head fillet area.



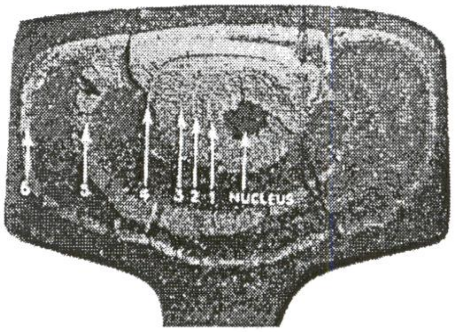
Welded burn fracture with transverse separation found beneath a resurfaced engine burn

Transverse Fissure

Is a progressive crosswise fracture starting from a crystalline center or nucleus inside the head from which it spreads outward as a smooth, bright, or dark, round or oval surface substantially at a right angle to the length of the rail. The distinguishing features of a transverse fissure from other types of fractures verse fissure or defects are the crystalline center or nucleus and the nearly smooth surface of the development which surrounds it.

Development of Transverse Fissures

The transverse fissure can be readily identified after a complete break occurs, by the presence of a nucleus within the defect.

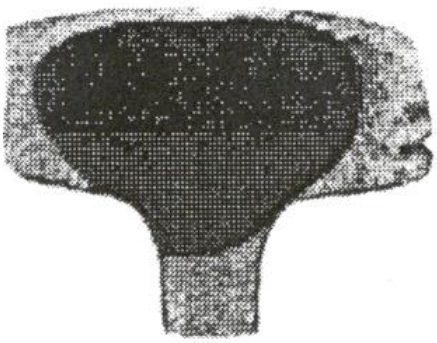


- This nucleus may have been caused by a shatter crack, a small inclusion of an impurity with the steel or a blowhole.

At first, the outward growth from such a defect is usually very slow. See the **MARTA Track Safety Standards** for required remedial action.

Face of transverse fissure was blackened or oxidized by air when separation reached surface at fillet

Since transverse fissures are caused by defects in the rail at the time of manufacture, the answer to the problem was sought in the rail manufacturing process.



- The solution was to be the adoption of the control cooling process.

The rate of cooling, after the rail is rolled, is controlled within specified limits by this procedure.

- Control cooling of rail was adopted by the steel mills in 1937 and has been highly successful in the prevention of' transverse fissures in rail manufactures since that time.

Where a transverse defect is located and positive identification cannot be made as to the type, the possibility that the defect is a transverse fissure must be considered, if the rail is not control cooled.

Rails, which are known or suspected to contain a transverse fissure, are dangerous for three reasons:

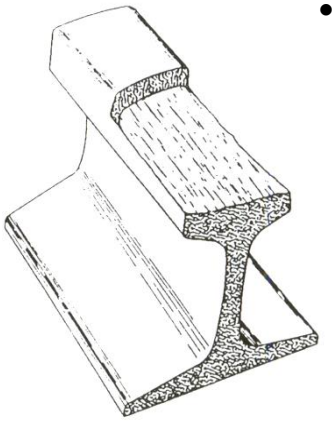
- The defects in the steel that cause transverse fissures are likely to he found at other locations within the same rail. Application of joint bars to a known transverse fissure offers no protection against failure elsewhere in the rail.

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

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

Longitudinal Defects in the Railhead

Longitudinal defects, such as vertical split heads and horizontal split heads are discovered in considerable numbers.



- Rail that has been relayed or otherwise disturbed after years of service in one position is particularly susceptible to the development of longitudinal defects due to altered stresses and changed loading patterns.
    - It has been noted that wheel-to-rail loading changes, which result from contour grinding, have aggravated certain dormant rail conditions.

Horizontal Split Head

Is a horizontal progressive defect originating inside of the railhead, usually one-quarter inch or more below the running surface and progressing horizontally in all directions, and generally accompanied by a flat spot on the running surface. The defect appears as a crack lengthwise of the rail when it reaches the side of the railhead.

Development of Horizontal Split Head

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

- The splits develop longitudinally (lengthwise in the rail) in a horizontal plane.
- They can be short or quite long before the head of the rail breaks out.
- If the split becomes transverse, the defect is classified as a compound fissure.

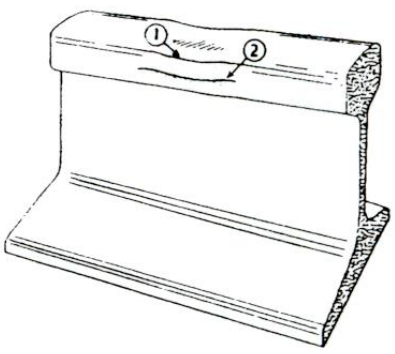
Evidence of horizontal split heads is usually visible before failure occurs. In the first stages, a flat spot or dip usually develops on the top of the railhead. There may be a slight widening of the head.

General appearance of a Horizontal Split Head

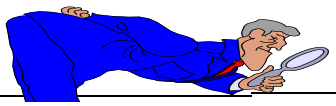
In the second stage, a horizontal crack appears on either the gauge or field side of the railhead. These conditions are illustrated in the figure below.

1) Before cracking out, a horizontal split head of moderate size will cause the appearance of a flat spot on the running surface, accompanied by a slight widening or dropping of the railhead. The flat spot will be visible as a dark spot on the bright running surface.

2) After cracking out, the horizontal split head will appear as a crack in either the field or gauge of head, or both, and at least 1/3, of the way below the top of the railhead. In rail laid without cant, the split will usually crack out first on the field side.



The horizontal split head is a serious defect because:



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

Vertical Split Head

is a vertical split through or near the middle of the head and extending into or through it. A crack or rust streak may show under the head close to the web or pieces may be split off the side of the head.

Development of Vertical Split Head

Internal segregation, seams or inclusions within the railhead also cause vertical split heads. They usually develop rapidly and lengths up to 10 feet are not unusual.

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

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

- When these signs appear, the existence of a vertical split may be further verified by looking under the railhead at the fillets between the head and web.
- A rust or dark streak or a bleeding crack is further evidence of the presence of such a defect.

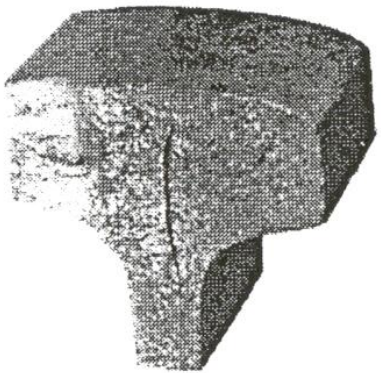
Visual Signs of Vertical Split Head

(1) A dark streak on the running surface.

(2) Widening of the head for the length of the split. The side of the head to which the split is offset may show signs of sagging or dropping.

(3) The dropping of the head causes a rust streak to appear on the fillet under the head.

(4) In advanced stages, a bleeding crack will be apparent at the fillet.



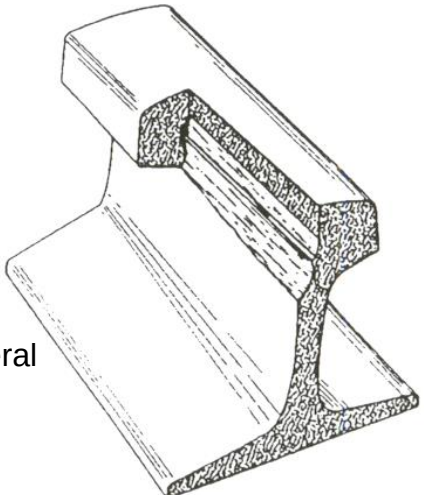
Vertical split heads usually grow to considerable size before such signs are visible.

The length of these defects increases the likelihood of severe disintegration of the rail when a piece breaks out of the railhead.

A vertical split head is a dangerous defect because:

- It is usually not visible on the surface until it has grown to a length of several feet.

Since a vertical split head usually extends longitudinally for some distance a considerable portion of the railhead is weakened.



If the split is on the gauge side of the rail and breaks off in service, car wheels will tend to climb to the top of the rail or drop between the rails causing a derailment.

- Upon service failure the rail may break into several pieces.

E. Web Defects

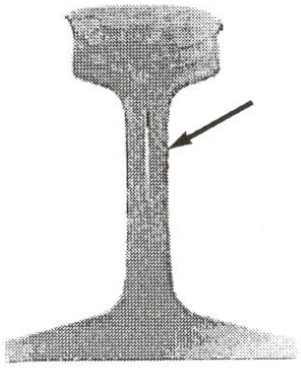
A web defect is any progressive fracture occurring in the web of the rail having, primarily, a longitudinal separation. These general classifications of defects can be identified on the rail as follows:

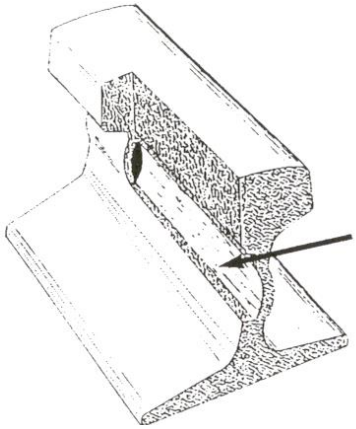
Piped Rail

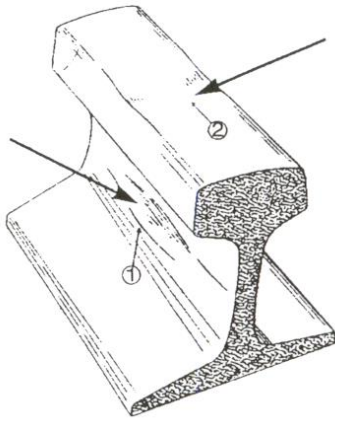
is a vertical split in a rail, usually in the web, due to failure of the shrinkage cavity in the ingot to unite in rolling.

Bulging of the web on either or both sides. Shallow cracks due to distortion may be found in the bulging surface.

- A slight sinking of the railhead is shown in the area above the pipe.







Development of Piped Rail

Piped rail is not a commonly found defect. The origin is a wide longitudinal seam or cavity inside the web, which extends vertically toward the head and base of the rail.

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

The original seam does not generally grow either vertically or horizontally. However, heavy loads may eventually cause it to spread or open up in a crosswise direction, so as to cause a bulge in the web. Internal seams that might cause little or no trouble under normal traffic conditions tend to open when subjected to pressure butt-welding.

Piped rail is a serious defect because:

- Rail is weakened for the distance of the pipe.

The head is not properly supported by the web, where the pipe exists. Upon the failure of service, the rail may break into several pieces.

Split Web

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

Development of Split Web

Split webs may be caused by a seam in the web or by external damage.

- At times, the cracks may bleed, making the defect more evident.

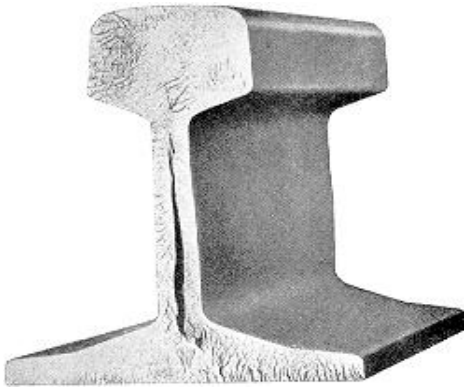
If the rail is not replaced, the defect will grow, turning upward and downward until a complete break occurs. The growth is usually rapid after the crack extends through the web, and is accelerated by unusual or heavy loading.

The split web is a serious defect because:

- The rail is weakened for the distance of the separation.
- Upon service failure, the rail may break into several pieces.

Web Defects in Joint Area

Joint area web defects are progressive fractures in the web area of the rail at or near the rail end and are generally associated with conditions resulting from bolted joints.



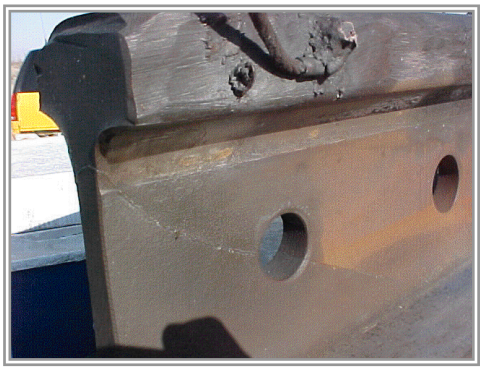
Two types of defects are included in this classification:

- Bolt hole crack
- Head and web separation

Bolt Hole Crack

is a crack across the web, originating from a bolt hole, and progressing on a path either inclined upward toward the railhead or inclined downward toward the base. Fully developed bolt hole cracks may continue horizontally along the head/web or base/web fillet, or they may progress into and through the head or base to separate a piece of the rail end from the rail. Multiple cracks occurring in one rail end are considered to be a single defect. However, bolt hole cracks occurring in adjacent rail ends within the same joint must be reported as separate defects.

Development of Bolt Hole Cracks



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

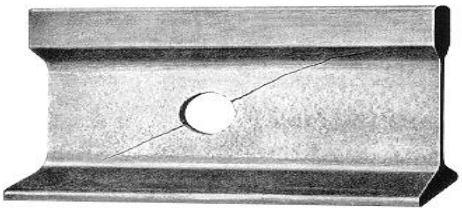
- After removal of the joint bar the defect may be recognized by a hairline crack extending from the bolt hole for the length of the defect.

Bolt hole cracks frequently result in a piece of the railhead breaking off within the limits of the joint bars.

- Occasionally, the cracks may progress beyond the joint bars and cause a complete transverse separation.

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

Bolt hole breaks are also developing on a somewhat horizontal plane particularly with respect to switch point heel joints, frog wing rails, railroad crossing rails, etc.



The growth of the bolt hole defect is erratic when compared with the predictable development of transverse defects in the railhead.

Head and Web Separation

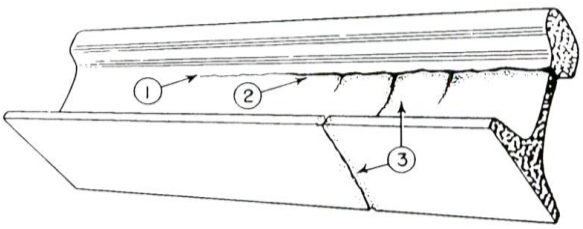
is a progressive fracture, longitudinally separating the head from the web of the rail at the head fillet area.

Acid action from some paving materials used at hi-rail accesses may start corrosion fatigue where the railhead joins the web.

Gravel at crossings, excessive speed on curves, or improper canting of the rail can cause unusual loading of the railhead.

- Fatigue then appears as rail strain, or a creped (wrinkled) fillet under the head.

1) extend downward Characteristics of a head and web separation in track from the longitudinal separation through the web, and In earlier stages wavy, wrinkled lines appear along the fillet under the head.
2) As the condition develops, small crack *will* appear along the fillet on either side, indicating growth through the web. It progresses longitudinally with slight irregular turns upward and downward.

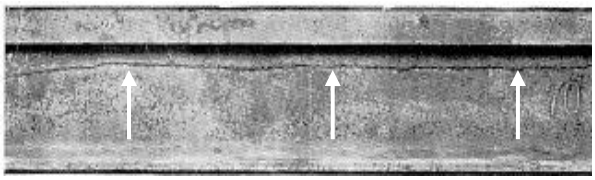


3) In advanced stages. Bleeding cracks will or may extend through the base.

Development of Head and Web Separation

The growth usually occurs in gradual stages but can develop quite rapidly under extreme stress conditions often created by pumping or swinging joints.

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



The head and web separations will appear as a hairline crack along the head fillet once the joint bars have been removed. With the joint bars in place, visual detection is not possible until the defect has reached an extremely advanced stage of development.

Head and web separation frequently occurs at hi-rail accesses where visual inspection is impossible. The separation occurs at hi-rail accesses because of the two different forces that are placed on the rail head.

- One of these forces is the load placed on the rail by the train
- The second is the force place on the rail head by the vehicles using the access.

Head and web separation is a serious defect because:

- The entire length of rail is greatly weakened for a distance in excess of the progressive separation.
- In the event of service failure under traffic, the rail is likely to break into several pieces.

F. Base Defects

A base defect is any progressive fracture originating in the base of the rail. This general classification covers two types of defects that can be identified in track:

- Broken base
- Base fracture

Broken Base

is any break in the base of the rail.

Development of Broken Base

A broken base defect is a progressive fracture in the base of the rail, with a vertical separation or split.

- The separation is substantially longitudinal, but usually turns out to the edge of the base. These separations are often called half-moon breaks.

Bearing on ties or tie plates or rail fasteners may cause the separation, or it may originate in a seam, segregation, or inclusion.

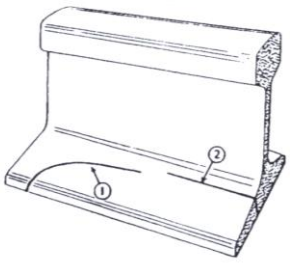
- The growth depends on the location of the break and the loading of the rail.

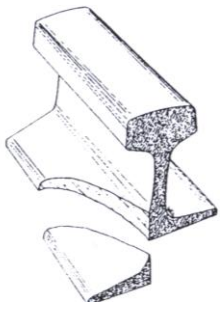
General appearance of a Broken Base

1) A crack starting near the junction of the base and web and extending outward to the edge of the base
2) A longitudinal crack extending along the junction of the web and base
3) A half moon break in the base of the rail.

The broken base is a serious *defect because:*

1) Remainder of the rail cross section becomes weakened
2) Upon complete failure, the rail may break into several pieces





Base Fracture

A base fracture is a progressive fracture in the base of the rail that develops substantially in a transverse plane.

These defects, as a rule, originate on the outer edge of the base.

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

- Improper rail handling sometimes causes damage of this nature.

Base fractures fall within the FRA definition of broken base.

Base fractures are visible as cracks for the extent of the progressive development into the rail. However, these defects are seldom found visually since a complete rupture usually occurs from a relatively small defect.

- The base fracture is a serious defect because of service failure that is usually a *complete break* of the rail across head, web and base. Also, failure *frequently occurs* before the defect can be discovered visually.

Damaged Rail

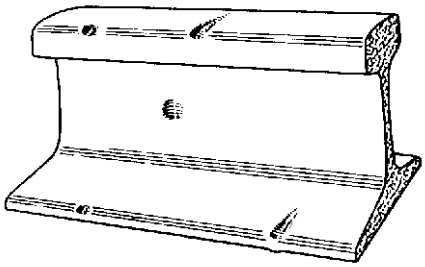
is any rail broken or inferred by wrecks, broken, flat, or unbalanced wheels, slipping, or similar causes.

Possible occurrences of Damaged Rail

One result of external damage can be a sudden rupture of the rail in the transverse direction.

- It is similar to the ordinary break, except that the break can be attributed to some event that caused it.

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



Another form of damage consists of nicks in the rail.

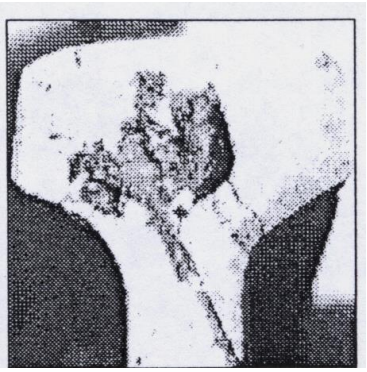
- Nicks can cause the development of defects.
- The likelihood of this happening is dependent upon the depth, sharpness, and location of the nick.

Track workers carelessly using a spike maul while spiking, or striking the rail while adjusting expansion may cause some nicks. Other nicks on the head of the rail are caused by broken wheels and these could be serious.

- When this occurs a qualified inspector should examine the rail and determine whether or not the rail should be replaced.

G. Defective Welds

is a field or plant (shop) weld containing any discontinuities or pockets, exceeding 5 percent of the rail head area individually or 10 percent in the aggregate, originated in or near the transverse plane, due to incomplete penetration of the weld metal between the rail ends, lack of fusion between weld and rail end metal, entrainment of slag or sand, under-bead or other shrinkage cracking, or fatigue cracking. Web defects may originate in the rail head, web, or base, and in some cases, cracks may progress from the defect into either or both adjoining rail ends.



A defective weld is most frequently a transverse defect, but sometimes, it is a longitudinal or split web type of defect, which can grow until complete failure occurs. Foreign matter on the faces of the rail ends can cause

it at the time of welding, by incomplete fusion during welding or by cracks caused by the heating of the rail during the welding process.

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

Defective plant weld

A defective plant weld may be a progressive transverse defect in the railhead within the area where two rails have been joined by a pressure welding process.

Defective plant welds may be caused by slag inclusions, oxide entrapments, improper fusion during the welding process, or thermal cracks that can result from rapid or otherwise improper cooling.

Web defects on a longitudinal plane through the weld may result from stress risers at shear drags, grinder gouges or residual stresses in rail ends prior to welding.

- Growth of a progressive head weld defect is normally slow.

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