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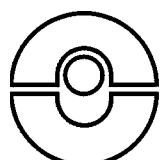
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4th edition, January 2002

Translation

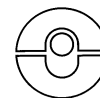
Rail defects

Défauts de rails
Schienenfehler



Union Internationale des Chemins de fer
Internationaler Eisenbahnverband
International Union of Railways

UIC



Leaflet to be classified in Section :

VII - Way and Works

Application :

With effect from 1 January 2002

All members of the International Union of Railways

This leaflet applies to standard gauge lines

Record of updates

| | |
|-----------------------------------|---|
| 1st edition, November 1956 | Compilation of the Catalogue of rail flaws and breakages for the use of track personnel. Compilation of the Withdrawal form for damaged and flawed rails. Compilation of the Standard statistical plan. |
| 2nd edition, June 1957 | Preparation of a leaflet on rail defects. |
| 3rd edition, January 1979 | Completion of UIC Leaflet 712 - Rail defects (June 1959). Revision of UIC Leaflet 712 - Rail defects (May 1965). Revision of UIC Leaflet 712 - Rail defects (June 1978). |
| 4th edition, January 2002 | Several types of defects added; main body of text and handbook incorporated in the leaflet |

The person responsible for this leaflet is named in the UIC Code



Warning

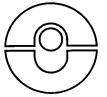
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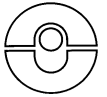
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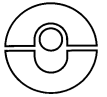


Summary

This leaflet contains recommendations for identifying and classifying rail defects and compiling statistics.

These defects are coded, described and illustrated in the Handbook of Rail Defects.

Appendix B defines a standard system for classifying broken, cracked and damaged rails according to the location, appearance and cause of the defects. It also explains ways and means of detecting such defects and recommends measures to be taken when rail defects are discovered in the track.



1 - Introduction

Irrespective of the rules specific to each railway, track maintenance will always involve the removal of a number of rails (or sections of rail) because of breakages or damage resulting from manufacturing defects and/or traffic loads.

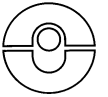
It is therefore essential to monitor the behaviour of rails in the track closely, so that users and producers can focus their efforts to improve the quality of the rails and at the same time the conditions for their use.

For monitoring to be consistent, reliable and suitable for computer processing, those responsible for maintenance and the design offices of technical departments are reliant on the quality of the information provided by the staff involved locally in rail maintenance and inspection operations on the tracks.

The information gathered must therefore be as precise as possible and must be communicated using clear, precise documents in easy-to-use form.

To harmonise the methods used for identifying, notifying and classifying rail defects and producing statistics, whilst also providing a basis for a constructive comparison of experience, it is recommended that UIC member railways:

- make use of the "**Handbook of Rail Defects**",
- draw up a "**withdrawal form of broken, cracked or damaged rails**" and compile "**statistics on rail defects**".



2 - Handbook of Rail Defects

The Handbook is intended for use by staff working on the track; with this in mind, it has been condensed wherever possible.

The introduction to the Handbook includes:

- a definition of rail defects,
- a definition of the recommendations,
- a definition of the location of the defects,
- the general coding system for rail defects.

For each type of broken, cracked or damaged rail there is a page giving one or more photographs of the defect in question and an explanatory text detailing, for each defect:

- its characteristics and appearance,
- means of detection,
- recommendations of a general nature that each railway can adapt to its own specific requirements.

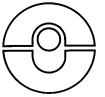
Because of the nature of certain defects, it is not always possible to establish their origin clearly from a visual inspection alone.

In cases such as these, the origin of the defect can only be determined by further examination in the laboratory.

Any reference to the assumed causes of the defect has no bearing on the railways' position with regard to the supplier where the guarantee is concerned.

Using the coding system selected, it will be possible to produce statistics rapidly by processing the information gathered directly by computer.

The Handbook is published by UIC Headquarters and available to UIC member railways.



3 - Withdrawal form for broken, cracked or damaged rails

This is a basic document designed for easy completion by each railway.

It is recommended that the different points listed in appendix A - page 6 be recorded for each defect.

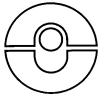
A withdrawal form is filled out for any rail or section of rail, including connecting rails on points and crossings, laid new on main line tracks¹ which has to be withdrawn prematurely because of breakage, cracking or damage, with the exception of the following cases:

- rails removed routinely due to wear,
- damage resulting from a traffic incident,
- special quality rails (not to specification),
- machined rails.

However, each railway shall still have the option of producing a withdrawal form to its own requirements for the cases mentioned above and for replacement rails.

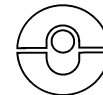
NB : Withdrawal forms should also be completed for broken, cracked or damaged rails *which are repaired by laying a new section of rail* and welds repaired in the track by welding, despite the fact that they remain in the track once the operation is completed.

1. According to the definition given in the "International Railway Statistics" published annually by UIC Headquarters, "main line tracks are tracks providing end-to-end line continuity and used for working regular trains between stations or places indicated in the tariffs as independent points of departure or arrival for the conveyance of passengers or goods".



4 - Rail defect statistics

The information supplied by the withdrawal forms constitutes a database that can be used for compiling statistics.



Appendix A - Checklist of headings to be used when compiling a withdrawal form

NB : Items marked with an asterisk (*) should be considered the basic minimum.

GENERAL INFORMATION

Breakage * or **Cracking or damage***

PRECISE LOCATION OF THE DEFECT IN THE TRACK

Line *

Track *

Rail *

Kilometre point *

DATE

Date the defect was discovered *

Date the defect was repaired or the broken rail removed *

HOW WAS THE DEFECT DETECTED ?

Ultrasonic testing

Other means of detection

CHARACTERISTICS OF THE LINE AND TRACK

Layout: Straight line * or **Curve ***

Curve radius *

UIC group classification *

Maximum speed *

Year laid

Method of laying: Standard sections * - **Continuous welded rail *** - with baseplates - without baseplates

Type of sleepers : Wooden - Concrete - Metallic - Slab track

Location : Open line - Tunnel (name)

Type of joint : Ordinary - Junctioned - Insulated - Glued insulated

CHARACTERISTICS OF THE RAIL

Rail condition: New or Reused

Rail profile *

Length of rail

Length of replacement rail

Rolling marks (in relief)

Stamped marks (embossed)

Steel grade *

Manufacturing process *

Total gross tonnage borne *

CHARACTERISTICS OF WELDS OR RESURFACING

Year carried out

Weld removed or repaired

Length of replacement rail

Profiles of the rails on either side of the weld

Steel grade of the rails on either side of the weld

Resurfacing: at rail end or away from rail end

CODE NUMBER OF DEFECT

As per the Handbook of Rail Defects *

ACTION TAKEN

Rail removed on or rail despatched to.....

DESCRIPTION OF THE DEFECT

Sketch showing where the defect was located, with indication of its size.



Appendix B - Handbook of rail defects

B.1 - Definition of rail defects

The following defects may occur in rails in the track:

- damaged rail;
- cracked rail;
- broken rail.

Damaged rail: a damaged rail is any rail which is neither cracked nor broken, but which has other defects, generally on the rail surface.

Cracked rail: a cracked rail is any rail which, anywhere along its length and irrespective of the parts of the profile concerned, has one or more gaps of no set pattern, apparent or not, the progression of which could lead to breakage of the rail fairly rapidly.

Broken rail: a broken rail is any rail which has separated into two or more pieces, or a rail from which a piece of metal becomes detached, causing a gap of more than 50 mm in length and more than 10 mm in depth in the running surface.

B.2 - Definition of recommendations

To make the recommendations more easily understandable, the following set expressions are used:

Keep rail under inspection

Applicable in case of defects that do not, at this stage, represent a hazard for operation.

Removal of the rail

Removal of the rail on occasion of a periodical or scheduled maintenance check.

Applicable to defects that do not represent an immediate hazard for operation but could develop into a potential hazard after the date of removal.

Immediate removal of the rail

Mandatory removal of the rail within a deadline to be set according to the characteristics of the defect, and the local conditions. This removal is the subject of a special intervention.

Applicable to defects representing a hazard for operation, but where the track nevertheless can be run if appropriate measures are taken.

Prohibition of traffic and immediate removal of the rail

Applicable to defects that do not permit any further use of the track, not even if special and provisional measures are taken.



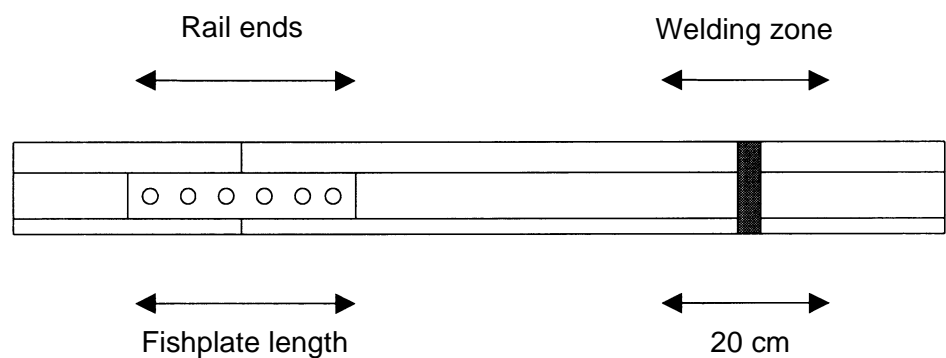
Comments

- Some rail defects are liable to worsen with time; where this is the case, a range of recommendations is made to cover the potential hazardousness of the defect at any given stage.
- In all cases, the defect must be kept under observation and the appropriate recommendations applied until the defect is eliminated.
- Ultrasound scans can be used:
 - to detect certain internal defects,
 - to check for possible internal growth of defects that originated at the surface.
- Visual inspection can be used:
 - to detect and monitor defects originating at the surface,
 - to monitor the growth of defects in the track.

B.3 - Definition of the location of defects

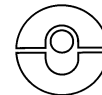
Rail defects may be located at the rail ends, away from the rail ends or in welding zones.

| | |
|---------------------------------|---|
| <i>Rail end:</i> | The part of the rail located at the level of the fishplates. |
| <i>Zone away from rail end:</i> | Zone comprising all parts of the rail located away from the rail ends and from the welding zones. |
| <i>Welding zone:</i> | The welding zone stretches 10 cm to either side of the centre-line of rail welds, in other words 20 cm in all. Any defect of internal origin occurring in the zone shall be classified as a welding defect. Defects of external origin shall be classified according to their own specific codes. |



B.4 - General coding of rail defects

Broken, cracked and damaged rails are given a code that may comprise up to 4 digits:



The first digit indicates:

1. defects in rail ends;
2. defects away from rail ends;
3. defects resulting from damage to the rail;
4. weld and resurfacing defects.

The second digit indicates:

- the place in the rail section where the defect originated;
- the welding method, in the case of weld and resurfacing defects.

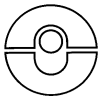
The third digit indicates:

- the pattern of the defect in the case of a broken or cracked rail;
- the nature of the defect in the case of a damaged rail;
- the cause of the defect in the case of a damaged rail.

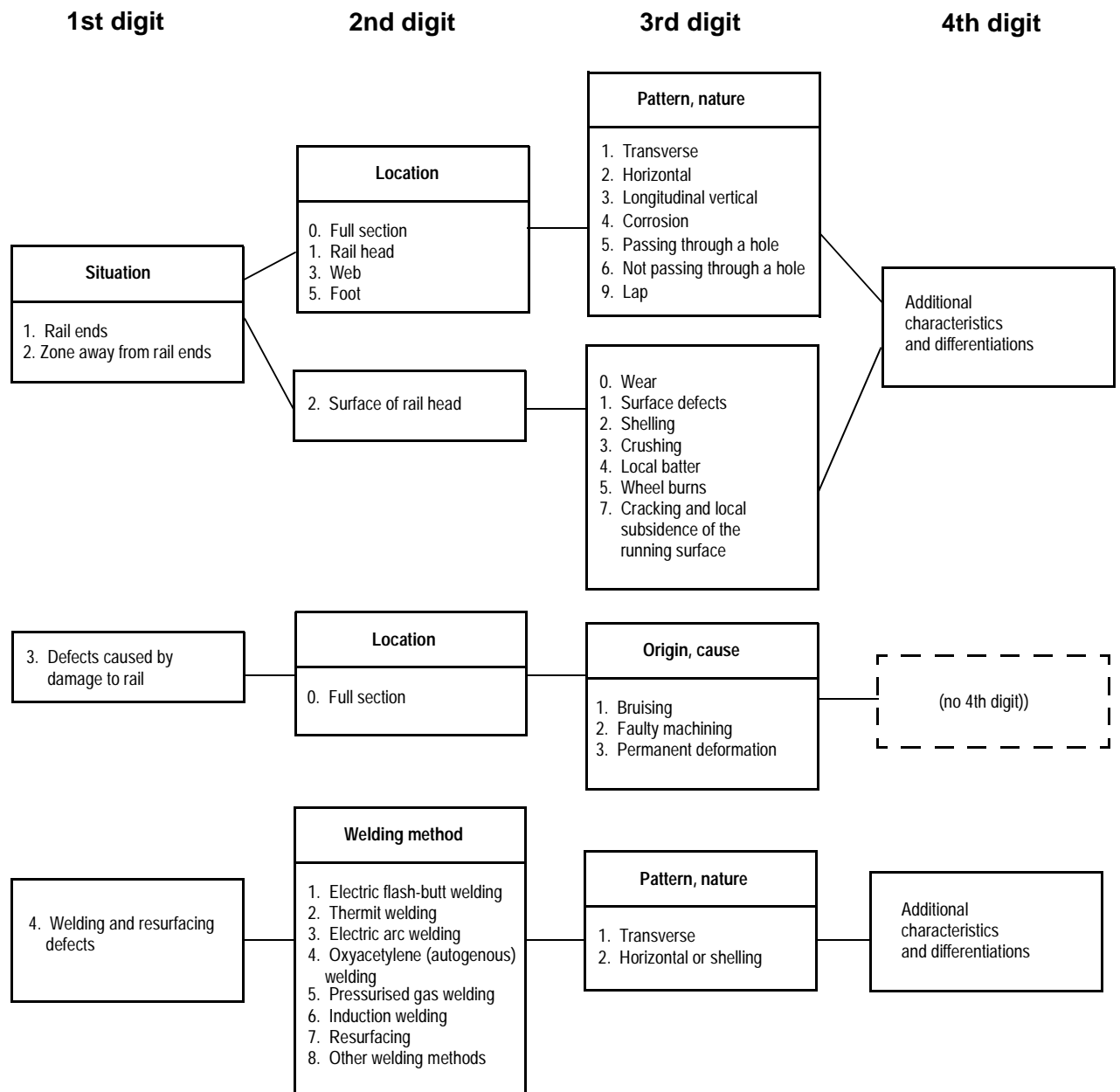
The fourth digit allows for a further classification based on the type of defect as and when required.

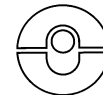
The general coding system for rail defects and the classification of the different types of defect are shown in the tables on points **B.5 - page 10** and **B.6 - page 11**.

Each defect is given a number and is described on a sheet indicating the characteristics and appearance of the defect, saying how it can be detected and giving recommendations as to what measures should be taken once it has been discovered.



B.5 - Rail defect coding system





B.6 - Classification and numbering of rail defects

1 Defects in rail ends

10 Full section

100 Transverse break without apparent origin

11/12 Head

111 Progressive transverse cracking (kidney-shaped fatigue crack)

112 Horizontal cracking

113 Longitudinal vertical cracking

121 Surface defects

122 Shelling of running surface

123 Crushing

124 Local batter of running surface

125 Wheel burns

13 Web

132 Horizontal cracking

1321 at the web-head fillet radius

1322 at the web-foot fillet radius

133 Longitudinal vertical cracking (piping)

134 Corrosion

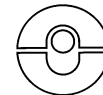
135 Star-cracking of fishbolt holes

139 Lap

15 Foot

153 Longitudinal vertical cracking

154 Corrosion



2 Defects away from rail ends

20 Full section

200 Transverse break without apparent origin

21/22 Head

- 211 Progressive transverse cracking (kidney-shaped fatigue crack)
- 212 Horizontal cracking
- 213 Longitudinal vertical cracking
- 220 Wear:
 - 2201 Short-pitch corrugation
 - 2202 Long-pitch corrugation
 - 2203 Lateral wear
 - 2204 Abnormal vertical wear
- 221 Surface defects
- 222 Shelling
 - 2221 Shelling of the running surface
 - 2222 Shelling of the gauge corner
 - 2223 Head checking / Fissuring / Scaling at the gauge corner
- 223 Crushing
- 224 Local batter of the running surface
- 225 Wheel burn
 - 2251 Isolated wheel burn
 - 2252 Repeated wheel burns
- 227 Squat / Cracking and local depression of the running surface

23 Web

- 232 Horizontal cracking
 - 2321 at the web-head fillet radius
 - 2322 at the web-foot fillet radius
- 233 Longitudinal vertical cracking (piping)
- 234 Corrosion
- 235 Cracking around holes other than fishbolt holes
- 236 Diagonal cracking away from any hole
- 239 Lap

25 Foot

- 253 Longitudinal vertical cracking
- 254 Corrosion



3 Defects caused by damage to the rail

30 Full section

- 301 Bruising
- 302 Faulty machining
- 303 Permanent deformation (warped rail)

4 Welding and resurfacing defects

41 Electric flash-butt welding

- 411 Transverse cracking of the profile
- 412 Horizontal cracking of the web

42 Thermit welding

- 421 Transverse cracking of the profile
- 422 Horizontal cracking of the web

43 Electric arc welding

- 431 Transverse cracking of the profile
- 432 Horizontal cracking of the web

44 Oxyacetylene welding (reserved)

45 Pressurised gas welding (reserved)

46 Induction welding (reserved)

47 Resurfacing

- 471 Transverse cracking of the rail head
- 472 Detachment or shelling of the resurfaced portion

48 Other welding methods

- 481 Transverse cracking under electrical connection



100

- 1 Defects in rail ends
- 10 Full section
- 100 TRANSVERSE BREAK WITHOUT APPARENT ORIGIN

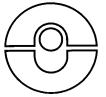
SEE DEFECT 200 - [page 37](#)



111

| | |
|-------|---|
| 1 | Defects in rail ends |
| 11/12 | Head |
| 111 | PROGRESSIVE TRANSVERSE CRACKING (KIDNEY-SHAPED FATIGUE CRACK) |

SEE DEFECT 211 - [page 39](#)



1 Defects in rail ends

11/12 Head

112 HORIZONTAL CRACKING

Characteristics and appearance

Manufacturing defect.

The horizontal cracking is characterised by the gradual separation of the upper part of the rail head (see - 112 (fig. 1) - page 17).

It starts inside of the rail head and progresses parallel to the running surface. A small crack appears on one or both faces of the head and on the end face in the gap of the expansion joint. It is sometimes accompanied by a vertical crack (see - 112 (fig. 2) - page 17). Not to be confused with 113 - page 18.

This crack may be combined with crushing of the rail end and a widening of the running surface is generally observed.

At a later stage, a piece of metal may break away (see - 112 (fig. 3) - page 17).

Not to be confused with 122 - page 21 (superficial defect due to traffic loads).

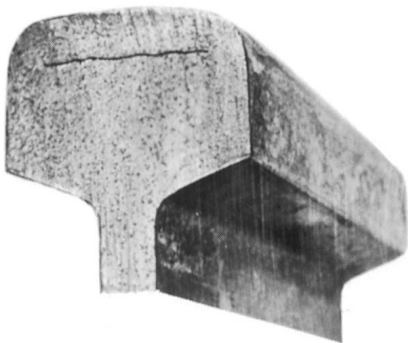
The separation is considered a breakage when the gap on the head is more than 10 mm deep and 50 mm long.

Means of detection:

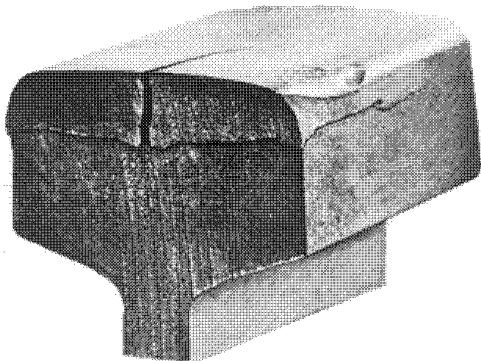
- visual inspection,
- hammer testing,
- ultrasonic testing.

Recommendations:

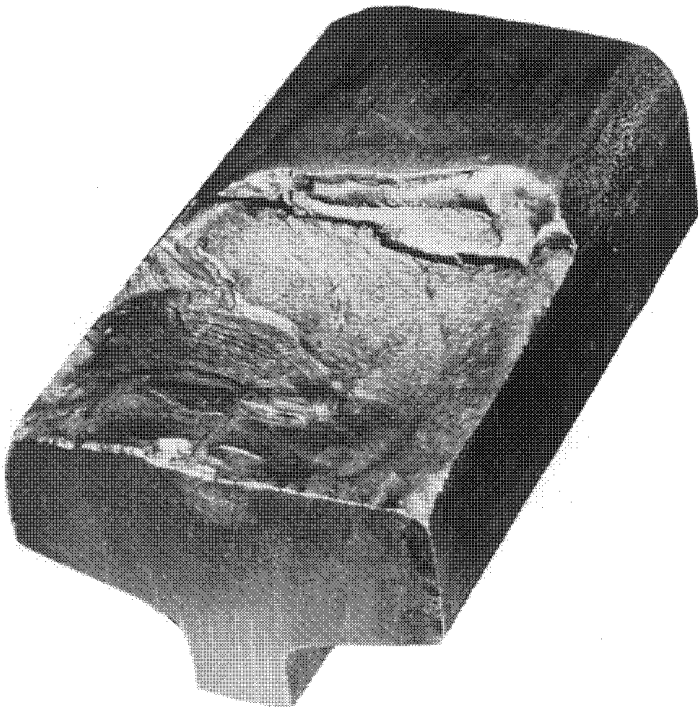
- keep cracked rail under inspection,
- remove the rail,
- immediate removal of the broken rail.



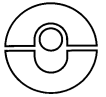
112 (fig. 1)



112 (fig. 2)



112 (fig. 3)



1 Defects in rail ends

11/12 Head

113 LONGITUDINAL VERTICAL CRACKING

Characteristics and appearance

Manufacturing defect.

This crack tends to divide the head gradually into two parts, following a plane parallel to the rail web (see - 213 - page 43).

When the defect reaches the running surface, it is identifiable by a black line on this surface. A depression of the running surface can then be observed as well as a widening of the head corresponding to the opening of the crack.

Not to be confused with 121 - page 20.

Means of detection:

- visual inspection,
- hammer testing,
- in case of doubt, remove the fishplates and inspect the web-head fillet area,
- ultrasonic testing.

Recommendations:

- immediate removal of the rail.



113

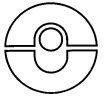


121

| | |
|-------|----------------------|
| 1 | Defects in rail ends |
| 11/12 | Head |
| 121 | SURFACE DEFECTS |

SEE DEFECT 221 - [page 53](#)





1 Defects in rail ends

11/12 Head

122 SHELLING OF RUNNING SURFACE

Characteristics and appearance

Defect due to traffic loads.

This defect, which starts at the surface, is characterised by the appearance of a small crack in the outer face of the head in the expansion gap, a few millimetres below the running surface. It is sometimes combined with a slight crushing of the rail end and the formation of a small lip in the gap corresponding to the extrusion of the metal.

At a later stage, a piece of the metal may break away.

Not to be confused with 112 - page 16 (manufacturing defect which originates at a greater depth).

Means of detection:

- visual inspection,
- hammer testing,
- ultrasonic testing.

Recommendations:

- repair by resurfacing,
- removal of the rail.



122

1 Defects in rail ends

11/12 Head

123 CRUSHING

Characteristics and appearance

Defect due to traffic loads.

A depression of the running surface is observed, as well as a widening of the tread.

The metal extrudes laterally and sometimes at the rail end. In extreme cases, a lip may form that will tend to break away from the rail.

Means of detection:

- visual inspection.

Recommendations:

- keep rail under inspection,
- grind the lips if necessary,
- repair by resurfacing.



123



124

| | |
|-------|---------------------------------|
| 1 | Defects in rail ends |
| 11/12 | Head |
| 124 | LOCAL BATTER OF RUNNING SURFACE |

SEE DEFECT 224 - [page 63](#)

| | |
|--------------------------|-------------------------------|
| Not to be confused with: | |
| - horizontal cracking | 112 - page 16 |
| - surface defect | 121 - page 20 |
| - shelling | 122 - page 21 |
| - crushing | 123 - page 22 |
| - wheel burn | 125 - page 24 |

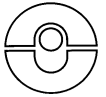


125

| | |
|-------|----------------------|
| 1 | Defects in rail ends |
| 11/12 | Head |
| 125 | WHEEL BURNS |

SEE DEFECTS 2251 - [page 64](#) and 2252 - [page 66](#)





1 Defects in rail ends

13 Web

132 HORIZONTAL CRACKING

1321 HORIZONTAL CRACKING AT THE WEB-HEAD FILLET RADIUS

Characteristics and appearance

This crack originates at the rail end and tends to separate the head from the web. Initially it progresses parallel to the web-head fillet (see - 1321 (fig. 1) - page 26) and may, as it develops, curve either upwards (see - 1321 (fig. 2) - page 26) or downwards, passing in some cases through a fishbolt hole (see - 1321 (fig. 3) - page 26) or simultaneously upwards and downwards (see - 1321 (fig. 4) - page 26).

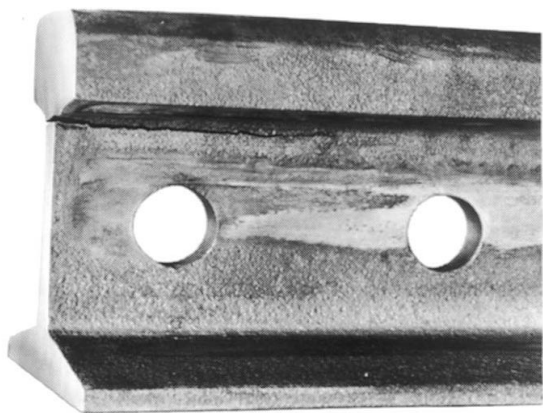
Not to be confused with 135 - page 32. In all cases, this crack causes the head to break away or leads to fragmentation of the rail.

Means of detection:

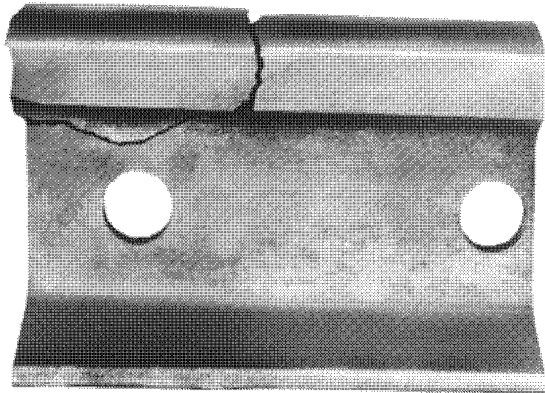
- hammer testing,
- visual inspection of both faces of the web after removal of the fishplates,
- ultrasonic testing.

Recommendations:

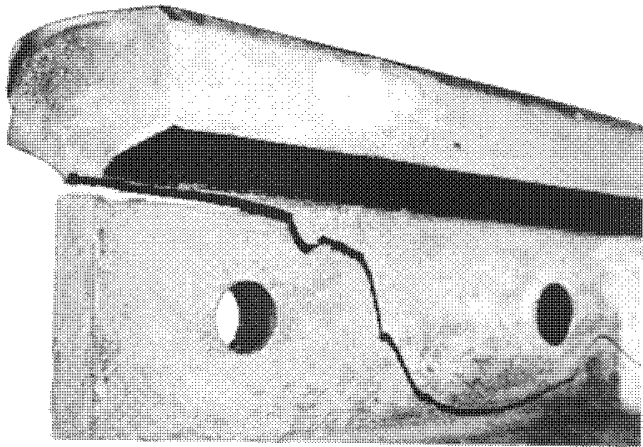
- removal of the cracked rail,
- immediate removal of the cracked rail,
- broken rail (see - 1321 (figs. 2 and 4) - page 26): prohibition of traffic and immediate removal of the rail.



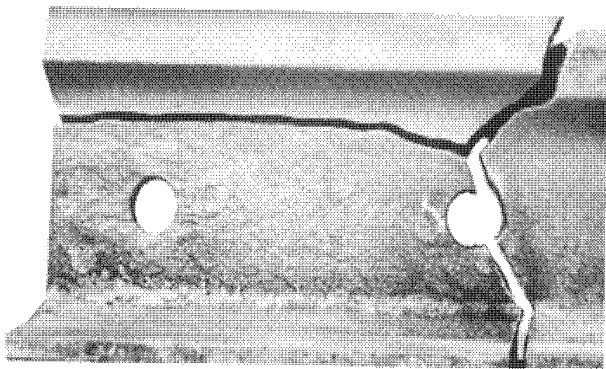
1321 (fig. 1)



1321 (fig. 2)



1321 (fig. 3)



1321 (fig. 4)



| | |
|----|----------------------|
| 1 | Defects in rail ends |
| 13 | Web |

| | |
|------|---|
| 132 | HORIZONTAL CRACKING |
| 1322 | HORIZONTAL CRACKING AT THE WEB-FOOT FILLET RADIUS |

Characteristics and appearance

This crack originates in the rail end and tends to separate the foot from the web. Initially it progresses parallel to the web-foot fillet (see - 1322 (fig. 1) - page 28) and, as it develops, curves generally downwards, causing the foot to break away (see - 1322 (fig. 2) - page 28).

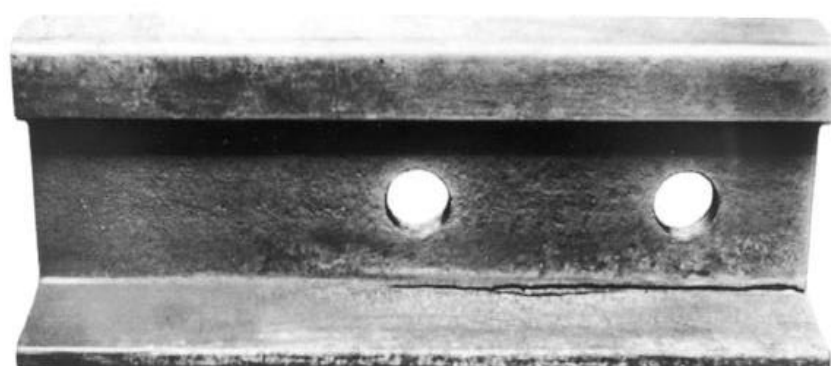
It may also curve simultaneously upwards, passing in some cases through a fishbolt hole and lead to breakage by fragmentation of the rail (see - 1322 (fig. 3) - page 28).

Means of detection:

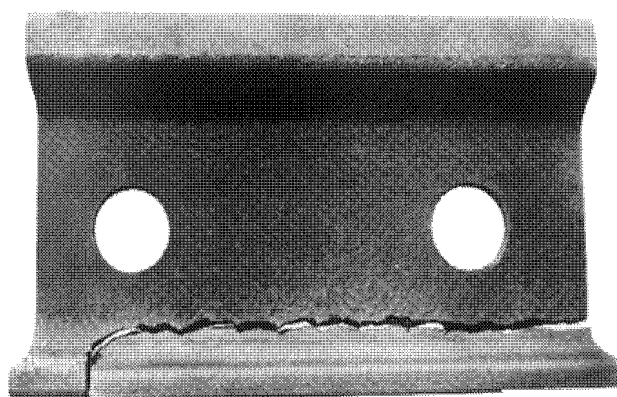
- visual inspection of both faces of the web after removal of the fishplates,
- ultrasonic testing.

Recommendations:

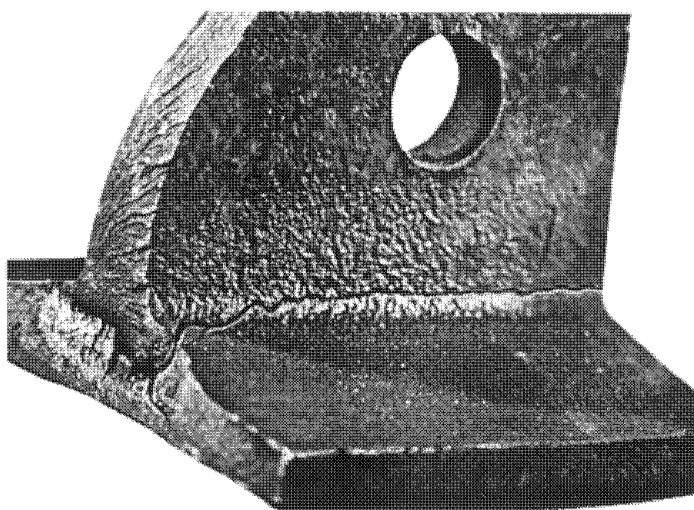
- removal of the cracked rail,
- immediate removal of the cracked rail,
- broken rail: prohibition of traffic and immediate removal of the rail.



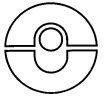
1322 (fig. 1)



1322 (fig. 2)



1322 (fig. 3)



1 Defects in rail ends

13 Web

133 LONGITUDINAL VERTICAL CRACKING (PIPING)

Characteristics and appearance

Manufacturing defect.

This defect, usually known as "piping", is characterised by a vertical discontinuity along the length of the rail web. It may cause the rail to break (see - 133 (figs. 1 and 2) - [page 30](#)) whether combined with another defect or not.

In exceptional cases, there may be a swelling of both web faces and a slight depression of the running surface at the level of the defect, or cracking around the fishbolt holes.

Means of detection:

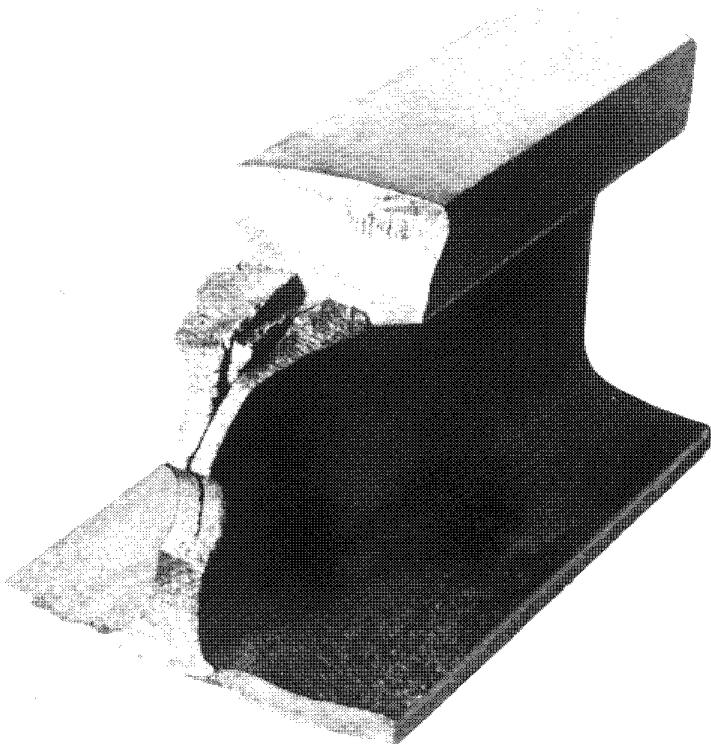
- visual inspection,
- ultrasonic testing.

Recommendations:

- keep rail under inspection,
- removal of the rail,
- immediate removal of the rail,
- prohibition of traffic and immediate removal of the rail ([see - 133 \(fig. 2\) - page 30](#)).



133 (fig. 1)



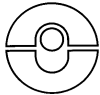
133 (fig. 2)



134

- 1 Defects in rail ends
- 13 Web
- 134 CORROSION

SEE DEFECT 234 - [page 76](#)



| | |
|----|----------------------|
| 1 | Defects in rail ends |
| 13 | Web |

135 STAR-CRACKING OF FISHBOLT HOLES

Characteristics and appearance

Defect due to traffic loads.

This defect consists of progressive cracks that radiate from the fishbolt holes (see - 135 (fig. 1) - page 33). They generally start at an angle of about 45° and can cause breakage (see - 135 (fig. 2) - page 33).

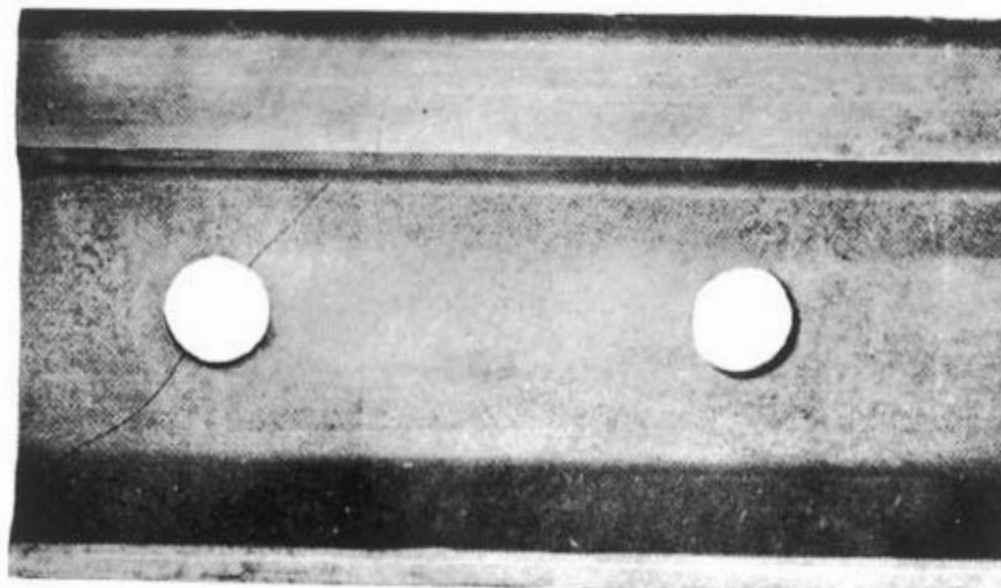
The probability of this type of defect forming depends heavily on the quality of drilling. Specific finishing techniques like bevelling and a good drilling surface quality can help to reduce the risk of cracking considerably.

Means of detection:

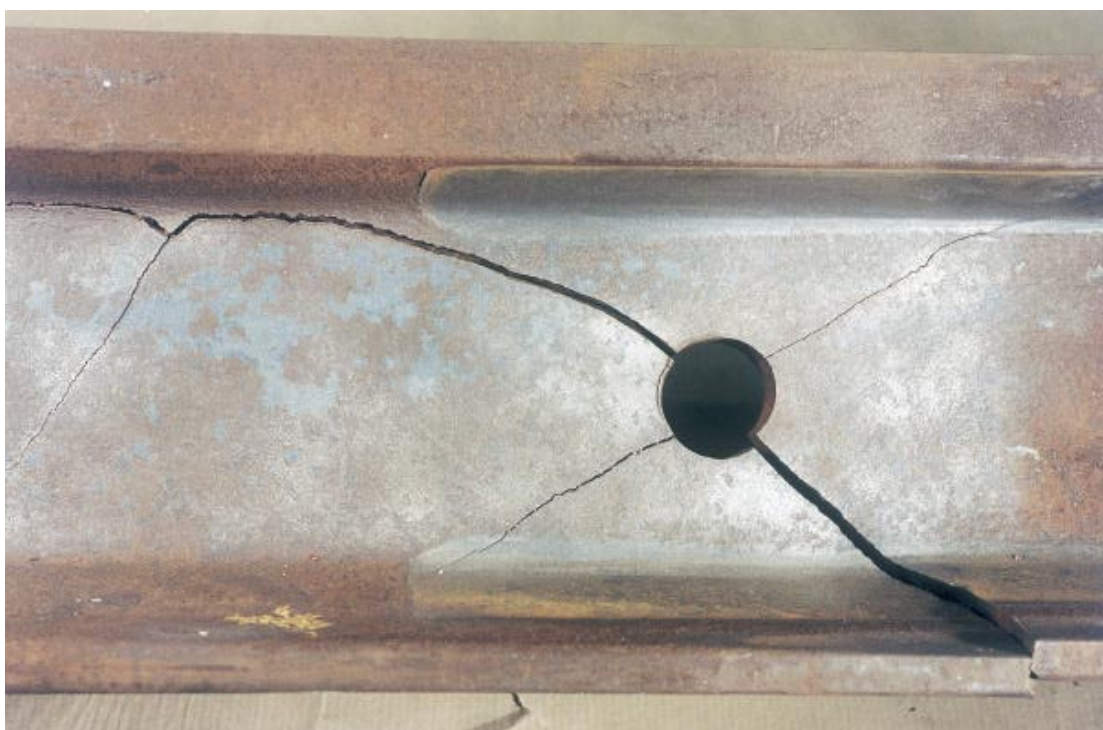
- visual inspection of both faces of the web after removal of the fishplates,
- ultrasonic testing.

Recommendations:

- removal of the cracked rail,
- immediate removal of the cracked rail,
- broken rail (see - 135 (fig. 2) - page 33): Prohibition of traffic and immediate removal of the rail.



135 (fig. 1)



135 (fig. 2)



139

- 1 Defects in rail ends
- 13 Web
- 139 LAP

SEE DEFECT 239 - [page 80](#)



153

- 1 Defects in rail ends
- 15 Foot
- 153 LONGITUDINAL VERTICAL CRACKING

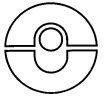
SEE DEFECT 253 - [page 81](#)



154

| | |
|-----|----------------------|
| 1 | Defects in rail ends |
| 15 | Foot |
| 154 | CORROSION |

SEE DEFECT 254 - [page 83](#)



2 Defects away from rail ends

20 Full section

200 TRANSVERSE BREAK WITHOUT APPARENT ORIGIN

Characteristics and appearance

A transverse break, the cause or origin of which cannot be determined immediately. Breaks of this type occur suddenly, more particularly during very cold weather.

Inspect the rail section involved and check in particular whether the break is not caused by:

- a progressive transverse crack starting within the head 211 - [page 39](#);
- wheel burns 2251 - [page 64](#), 2252 - [page 66](#);
- corrosion 234 - [page 76](#), 254 - [page 83](#);
- longitudinal vertical cracking in the foot 253 - [page 81](#);
- bruising 301 - [page 85](#);
- faulty machining 302 - [page 88](#);
- etc.

Means of detection:

- visual inspection.

Recommendations:

- carry out temporary fishplating,
- immediate removal of the broken rail.



200



2 Defects away from rail ends

21/22 Head

211 PROGRESSIVE TRANSVERSE CRACKING (KIDNEY-SHAPED FATIGUE CRACK)

Characteristics and appearance

Manufacturing defect.

This defect (see - 211 (figs. 1 and 2) - [page 40](#)) develops from a defect inside the rail head, from an internal horizontal crack or very exceptionally from deep shelling of the gauge corner. The position of the point of origin is not necessarily central (see - 211 (fig. 5a and 5b) - [page 40](#)). The appellation "kidney-shaped" is explained by the characteristic shape of this progressive crack. Not to be confused with transverse cracking under resurfacing 471 - [page 102](#), nor with progressive transverse cracks on welds 411 - [page 91](#), 421 - [page 95](#), 431 - [page 99](#), 481 - [page 106](#). After a certain time, the crack reaches the outer region of the rail head (see - 211 (fig. 3) - [page 40](#)). It then becomes visible on the faces of the web (see - 211 (fig. 4) - [page 40](#)). Breakage of the rail is imminent at this stage.

This defect can not be identified with certainty until breakage has occurred. However, the presence of an oblique transverse crack, generally exclusive of any other defect in the rail head surface, is a reliable indication of a kidney-shaped fatigue crack.

When the breakage occurs before the defect becomes visible, a smooth, shiny kidney-shaped patch can be observed, generally combined with concentric zones denoting the progression of the crack (see - 211 (fig. 5a and 5b) - [page 40](#)). The patch starts oxidising as soon as the crack reaches the surface and becomes visible.

This serious defect can occur repeatedly in the same rail and thereby result in large gaps in the event of multiple breaks. It may develop into an epidemic for rails of the same cast.

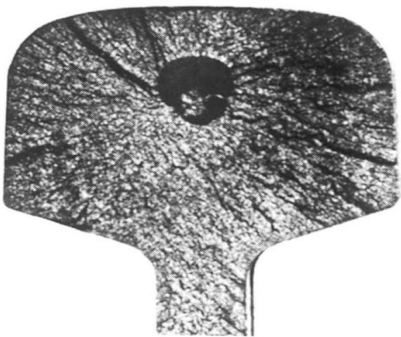
Means of detection:

- visual inspection,
- ultrasonic testing.

Recommendations:

depending on the extent of the defect(s):

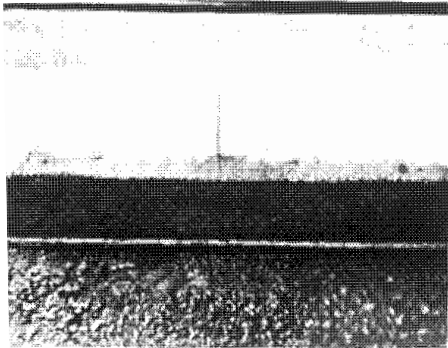
- keep the rail under inspection,
- carry out temporary fishplating,
- removal of the rail,
- immediate removal of the rail,
- if possible, conduct an ultrasound scan of rails from the same cast when the defect occurs on an epidemic scale.



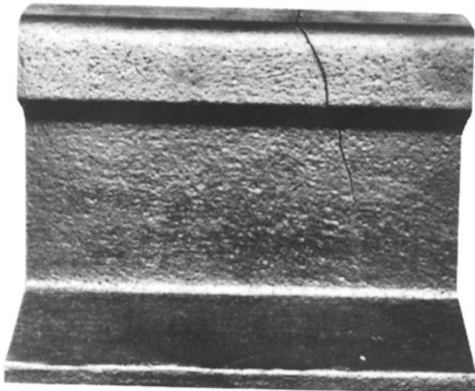
211 (fig. 1)



211 (fig. 2)



211 (fig. 3)



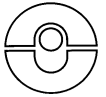
211 (fig. 4)



211 (fig. 5a)



211 (fig. 5b)



2 Defects away from rail ends

21/22 Head

212 HORIZONTAL CRACKING

Characteristics and appearance

Manufacturing defect.

This crack tends gradually to separate the upper part of the head following a plane approximately parallel to the running surface (see - 112 - page 16).

It may result in local depression of the running surface which may be characterised by a dark patch contrasting with the shiny surface of the running tread.

Initially, a crack becomes visible on the outer face of the head at a distance generally of some 15 mm from the running surface (see - 212.1 - page 42).

The horizontal crack may curve downwards and give rise to a transverse crack (see 212.2 - page 42 - compound crack) and ultimately to breakage.

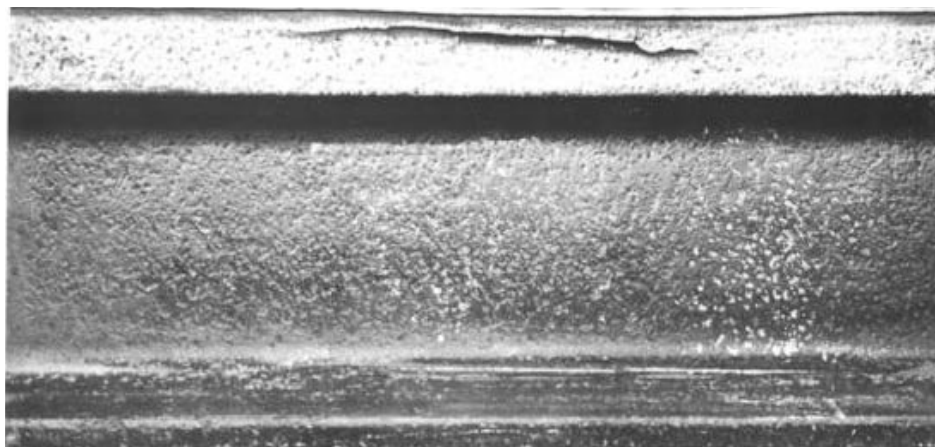
A broken rail caused by a compound crack is characterised, when the breakage starts, by a dark patch in the region where the original horizontal crack was located. The rest of the fracture has a clear, crystalline appearance.

Means of detection:

- visual inspection,
- ultrasonic testing.

Recommendations:

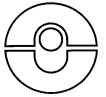
- keep the rail under inspection,
- removal of the rail,
- immediate removal of the rail.



212.1



212.2



2 Defects away from rail ends

21/22 Head

213 LONGITUDINAL VERTICAL CRACK

Characteristics and appearance

Manufacturing defect.

This crack tends gradually to separate the head into two parts following a plane parallel to the rail web. As soon as the defect reaches the running surface, it is characterised by a black line along the surface (see - 213 (fig. 1) - page 44). A depression of the running surface can then be observed together with a widening of the head corresponding to the opening of the crack.

The crack may also become visible in the web-head fillet radius of one of the two faces of the web (see - 213 (fig. 2) - page 44).

Figures 1 and 2 show the defect in the same rail.

When the defect becomes visible on the running surface, it should not be confused with 221.2 (see page 53) and 221.3 (see page 53).

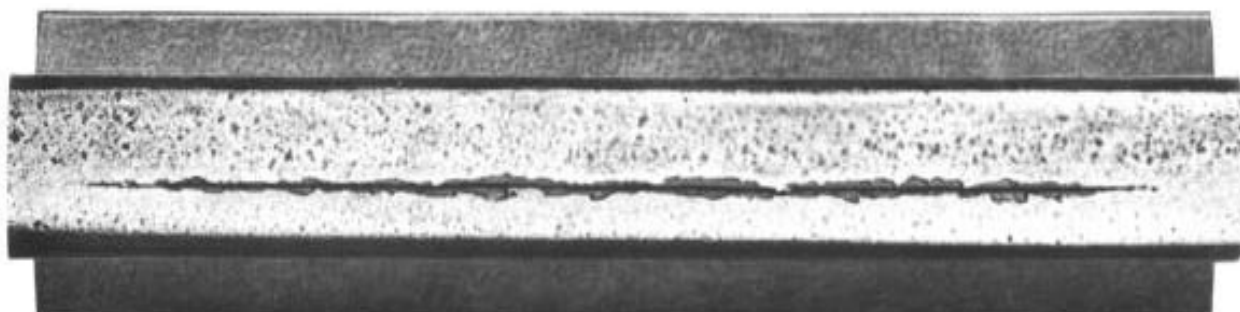
When the defect becomes visible in the web-head fillet radius, it should not be confused with 2321 - page 70 or 239 - page 80. It may be possible to distinguish between them by conducting an ultrasound scan.

Means of detection:

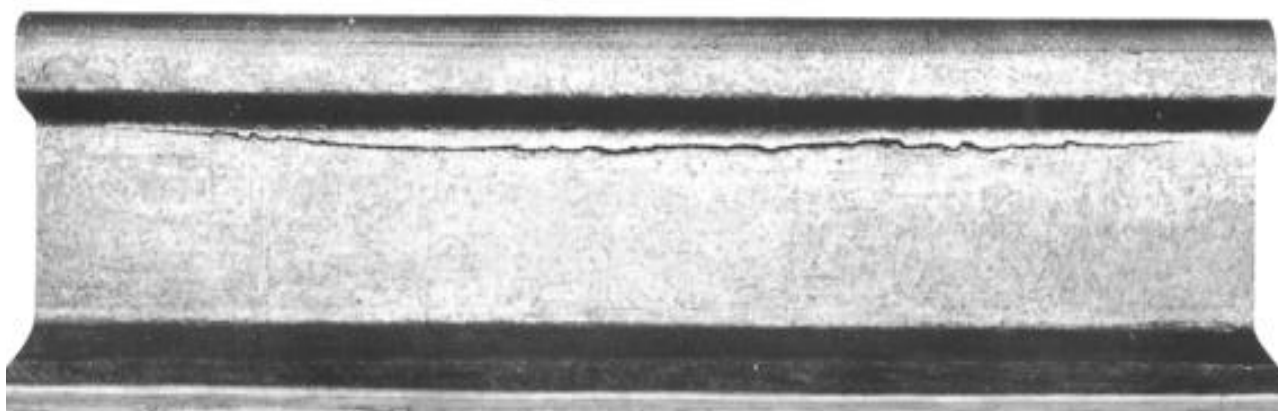
- visual inspection,
- hammer testing,
- ultrasonic testing.

Recommendations:

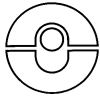
- immediate removal of the rail.



213 (fig. 1)



213 (fig. 2)



2 Defects away from rail ends
21/22 Head

220 WEAR

2201 SHORT-PITCH CORRUGATION

Characteristics and appearance

Defect due to traffic loads.

Short-pitch corrugation is characterised by a pseudo-periodical sequence of bright ridges and dark hollows on the running surface. The pitch generally varies between 3 and 8 cm.

Means of detection:

- visual and sonic inspection,
- observations based on recordings made by track inspection vehicles,
- recordings by means of purpose-built vehicles.

Recommendations:

grind rails when corrugation is on a scale prejudicial to:

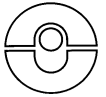
- track maintenance,
- the running gear of vehicles,
- passenger comfort,
- the environment (high noise level due to passing trains).



2201 (fig. 1)



2201 (fig. 2)



2 Defects away from rail ends

21/22 Head

220 WEAR

2202 LONG-PITCH CORRUGATION

Characteristics and appearance

Defect due to traffic loads.

With this type of corrugation, there is no difference in appearance between ridges and hollows.

Long-pitch corrugation is characterised by depressions in the running surface which are more or less pronounced and uneven in relation to an ideal rectilinear profile.

The pitch generally varies between 8 and 30 cm approximately.

Long-pitch corrugation generally occurs on the inside stretches of curves.

Means of detection:

- visual and sonic observation,
- observations based on recordings made by track inspection vehicles,
- recordings by means of purpose-built vehicles.

Recommendations:

grind rails where corrugation is on a scale prejudicial to:

- track maintenance,
- the running gear of vehicles,
- passenger comfort,
- the environment (high level of noise due to passing trains).



2202



| | |
|-------|-----------------------------|
| 2 | Defects away from rail ends |
| 21/22 | Head |

| | |
|-----|------|
| 220 | WEAR |
|-----|------|

| | |
|------|--------------|
| 2203 | LATERAL WEAR |
|------|--------------|

Characteristics and appearance

The lateral wear (or bevelling) of rails located on the outside stretches of curves results from rolling-stock stresses. In the same curve, this wear generally takes on a sinusoidal appearance with a minimum value at the level of the fishplated joints.

The progression of lateral wear depends on the quality of rail lubrication to a very large extent.

Lateral wear constitutes a defect when its extent is:

- prejudicial to track maintenance (excessive gauge widening);
- likely to cause breakage through weakening of the profile (affecting the lower fillet of the head).

Means of detection:

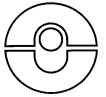
- visual observation and measurement of the wear.

Recommendations:

- keep rail under inspection and measure the wear,
- removal of rails showing abnormal lateral wear.



2203



2 Defects away from rail ends

21/22 Head

220 WEAR

2204 ABNORMAL VERTICAL WEAR

Characteristics and appearance

Defect due to traffic loads.

Vertical wear results from rolling-stock stresses and progresses in line with the traffic load. Generally speaking, it is not a rail defect as such.

However, abnormal vertical wear may occur on some rails. Its extent in such cases clearly exceeds the average wear noted on adjacent rails under similar conditions.

Not to be confused with 223 - [page 62](#).

This abnormal wear may cause breakage through weakening of the profile. (In such cases, check that breakage does not result from another defect).

Means of detection:

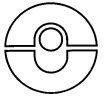
- visual inspection and measurement of the wear.

Recommendations:

- removal of rails showing abnormal vertical wear,
- grind lips if necessary, pending removal.



2204



2 Defects away from rail ends

21/22 Head

221 SURFACE DEFECTS

Characteristics and appearance

Manufacturing defects.

Not visible or hardly visible at the outset, these defects become apparent in the track after a time-interval which varies according to the traffic load.

Surface defects may present any one of the following characteristics in the course of their development.

- Flaking (221.1): Thin flakes of metal which break away from the running surface (see - 221.1 (fig. 1) - page 54). The defect may be up to several millimetres deep, causing a gradual depression in the running surface (see - 221.1 (fig. 2) - page 54).

Not to be confused with 224 - page 63 or 225 - page 64.

- Long groove (see - 221.2 - page 54): A strip of metal of approximately constant section breaks away from the running surface. The defect may be up to several metres in length. Its depth does not exceed a few millimetres.

Not to be confused with 213 - page 43.

- Line (see - 221.3 - page 54): Filiform longitudinal defect which does not exceed 2 to 3 mm in depth. This defect, which becomes apparent soon after the rail is laid, generally tends to disappear gradually as the running surface wears, unless it is combined with flaking (221.1).

Not to be confused with 213.

Means of detection:

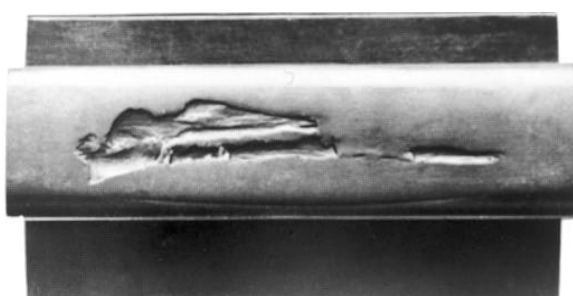
- visual inspection.

Recommendations:

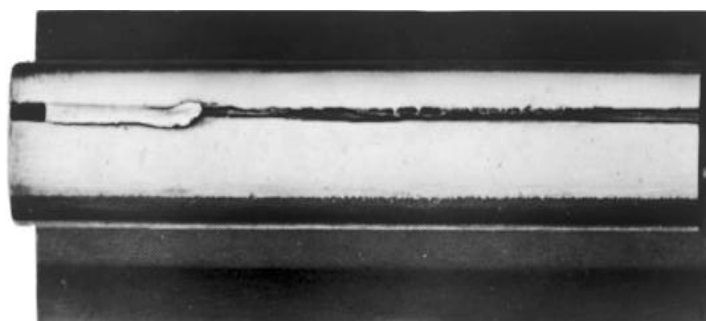
- keep rail under inspection,
- if the defect is not too deep, it may be possible to remove it by grinding,
- defects which are not too deep and are localised may lend themselves to repair by resurfacing,
- removal of the rail if defect should extend and become prejudicial to track maintenance.



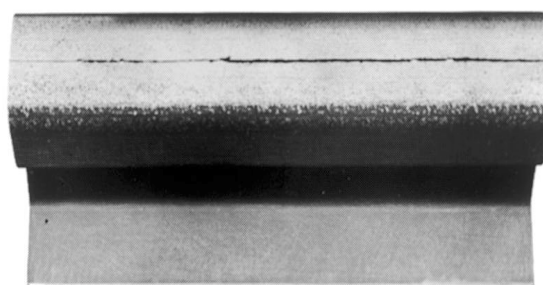
221.1 (fig. 1)



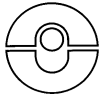
221.1 (fig. 2)



221.2



221.3



2221

- 2 Defects away from rail ends
- 21/22 Head

222 SHELLING

2221 SHELLING OF THE RUNNING SURFACE

Characteristics and appearance

Pseudo-undulatory deformation of the running surface (see - 2221 (fig. 1) - page 56) is observed prior to the formation of shells in the metal, which can be up to several millimetres deep (see - 2221 (fig. 2) - page 56). The cross-section of these shells is extremely variable.

Not to be confused with: 221 - page 53, 2251 - page 64, 227 - page 68.

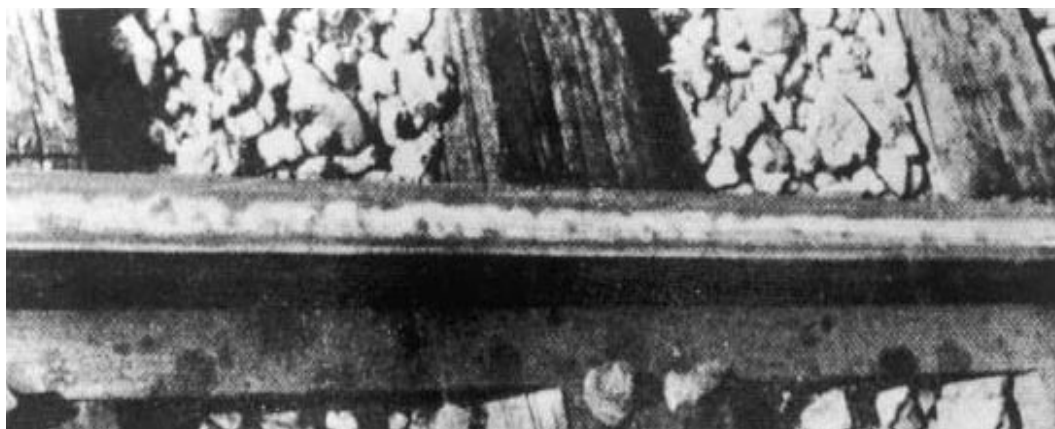
Shelling is generally not an isolated defect and most often occurs in several zones.

Means of detection:

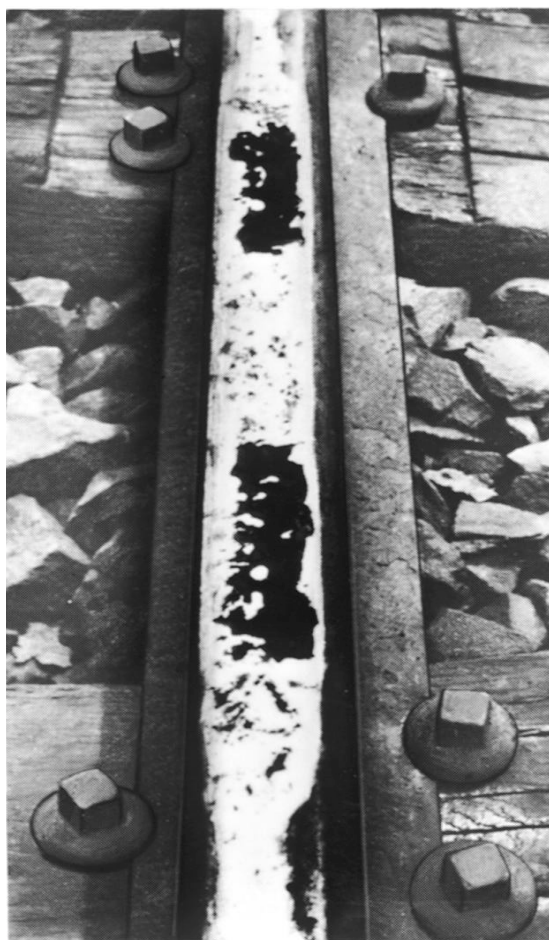
- visual inspection,
- ultrasonic testing.

Recommendations:

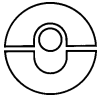
- keep rail under inspection,
- removal of the rail,
- immediate removal of the rail.



2221 (fig. 1)



2221 (fig. 2)



2 Defects away from rail ends

21/22 Head

222 SHELLING

2222 SHELLING OF THE GAUGE CORNER

Characteristics and appearance

The rails first show long dark spots randomly spaced out over the gauge corner of the rail head (see - 2222 (fig. 1) - page 58). These spots are early signs of underlying metal disintegration which, after a period of evolution, are characterised by the formation of lips on the side face, of cracks and, lastly, of shelling in the gauge corner of the running surface which can sometimes be quite extensive (see - 2222 (fig. 2 and 3) - page 58). At this stage in the process, the metal creep caused by traffic loads leads to simultaneous local depressions in the running surface.

Generally speaking, gauge-corner shelling occurs on the outside rails in curves lubricated to avoid lateral wear.

Check that this defect is not accompanied by or giving rise to transverse cracking (see - 211 - page 39).

Means of detection:

- visual inspection,
- ultrasonic testing.

Recommendations:

- keep rails under inspection,
- removal of the rail,
- immediate removal of the rail.



2222 (fig. 1)



2222 (fig. 2)



2222 (fig. 3)



2 Defects away from rail ends

21/22 Head

222 SHELLING

2223 HEAD CHECKING / FISSURING / SCALING AT THE GAUGE CORNER

Characteristics and appearance

Head-checking shows generally at the gauge corner of the higher stretch of rails, in curves. It looks like small, parallel fissures regularly spaced or not. The distance between fissures varies according to local conditions and railsteel grading, going from 1 mm to several cm.

Head-Checking takes the following shapes :

1. Stabilised and regular H-C (see - 2223 (fig. 1) - page 60).
2. H-C with scaling (see - 2223 (fig. 2) - page 60). Fissures inside the railhead progress according to an angle going from 10° to 15°, up to maximum depth that is, in certain instances, several mm. They then progress in a parallel to the running surface of the rail and end up meeting again in the gauge corner where they generate scaling.

In certain unusual cases (see - 2223 (fig. 1) - page 60 and (fig. 3) - page 61), a breaking may occur due to H-C fissures growing transversally (see - 2223 (fig. 4) - page 61).

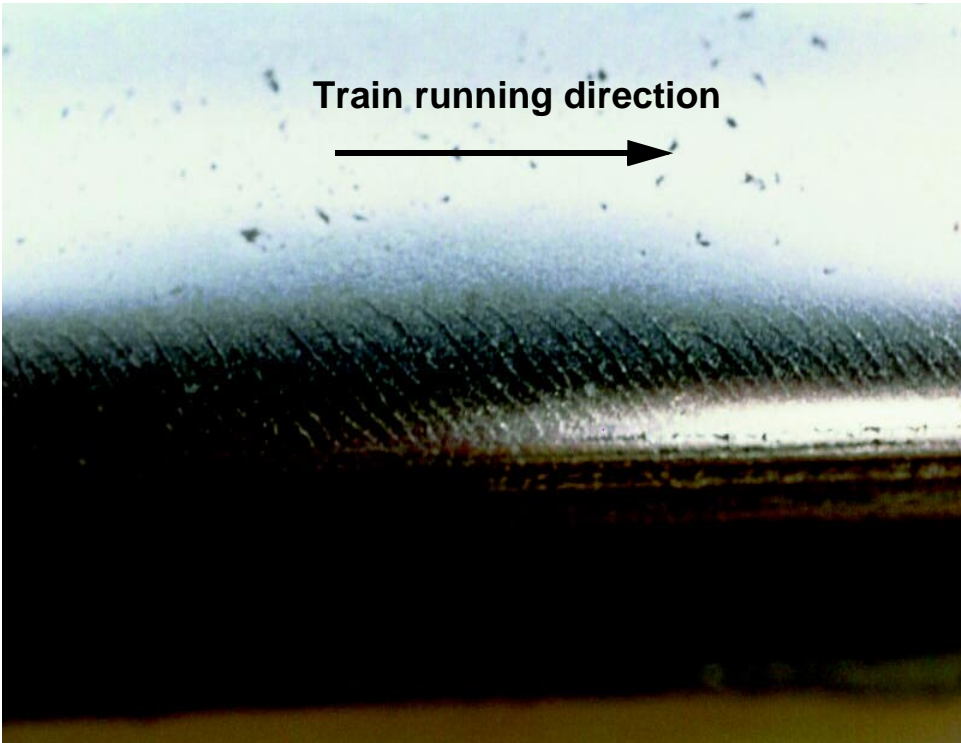
3. H-C that looks like a long fissure, ending at the top in a ramification following the longitudinal axis of the rail (see - 2223 (fig. 3) - page 61). With this type of H-C, there is also a small dark-looking dimple upstream. The running surface of the rail often shows a widening. This defect looks like defect no. 227 - page 68 (squat), but for its location in the gauge corner. If recurring periodically, that defect may result in multiple breaking over several metres, being as such particularly dangerous.

Means of detection:

- visual inspection,
- ultrasonic testing.

Recommendations:

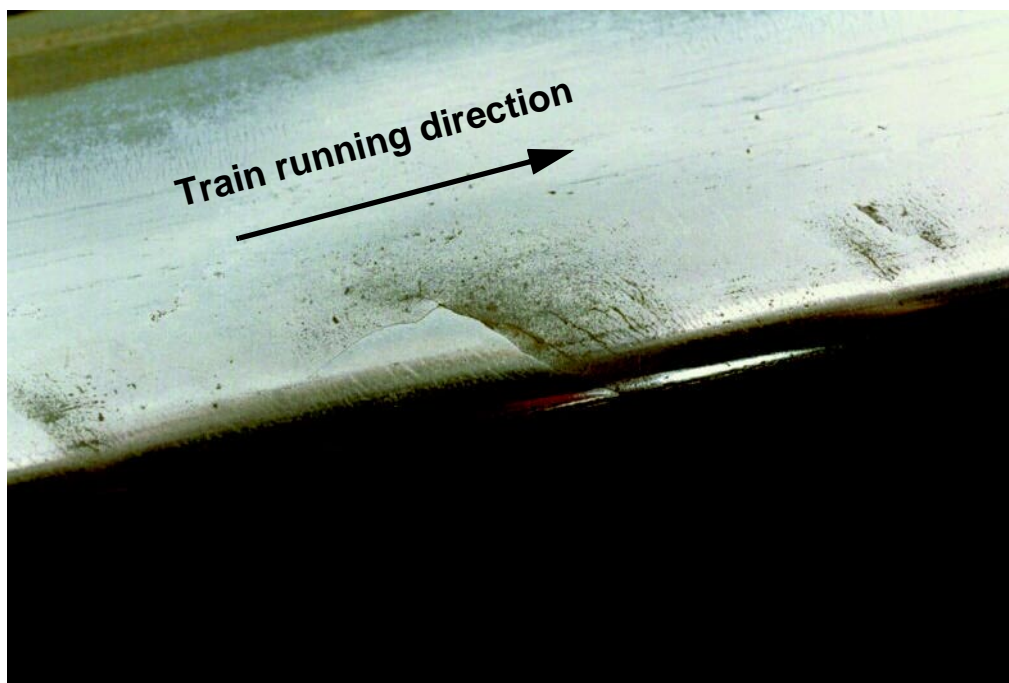
- keep rail under inspection,
- withdrawal of the rails showing defects endangering running safety or quality,
- grinding the rail sometimes makes it possible to prevent or delay scaling,
- removal of the broken rail.



2223 (fig. 1)



2223 (fig. 2)



2223 (fig. 3)



2223 (fig. 4)

2 Defects away from rail ends

21/22 Head

223 CRUSHING

Characteristics and appearance

The running surface of the rail extrudes laterally over a considerable distance.

The upper outside corner of the rail mushrooms over to form a lip.

The formation of a seam is then observed, which can extend over the full length of the rail. This seam tends to taper out and progressively break away from the head.

This defect generally appears on the inside rail of small-radius curves.

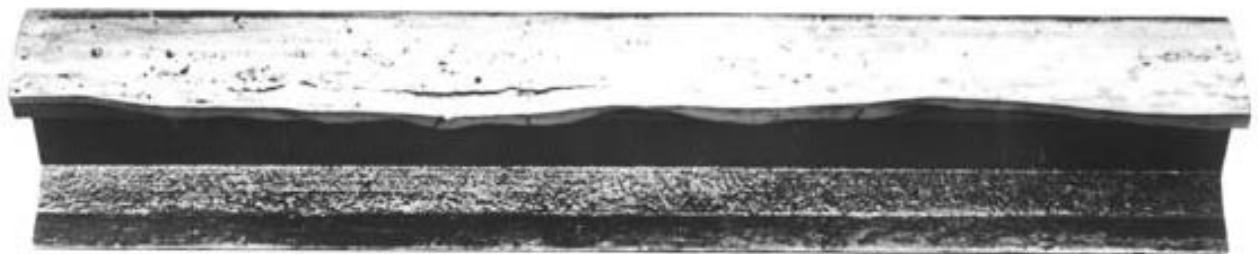
Not to be confused with 2204 - [page 51](#).

Means of detection:

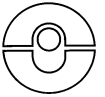
- visual inspection.

Recommendations:

- keep rail under inspection,
- grind the seams if necessary,
- removal of the rail.



223



2 Defects away from rail ends

21/22 Head

224 LOCAL BATTER OF RUNNING SURFACE

Characteristics and appearance

Manufacturing defect.

Unusual defect, the exact origin of which cannot be identified immediately.

The running surface shows an isolated, fairly short hollow, which is generally accompanied by a widening of the running tread.

Not to be confused with: 212 - [page 41](#), 221 - [page 53](#), 223 - [page 62](#), 2251 - [page 64](#).

Means of detection:

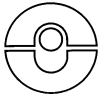
- visual inspection.

Recommendations:

- keep rail under inspection,
- removal of the rail,
- immediate removal of the rail.



224



2 Defects away from rail ends

21/22 Head

225 WHEEL BURN

2251 ISOLATED WHEEL BURN

Characteristics and appearance

Defect due to traffic loads.

The slipping of a driving axle can cause the formation of an elliptical-shaped self-quenched layer.

This layer may disappear, or develop:

- either horizontally in the head, where it soon degenerates into local shelling which does not develop in depth but progressively causes depression of the running surface under repeated traffic loads (see - 2251 (fig. 1) - page 65) and (see - 2251 (fig. 2) - page 65).

Not to be confused with 221.1 - page 53, 227 - page 68.

- or transversally in the head, resulting in an internal crack which progresses towards the web and is accompanied by a depression of the running surface without any other local alteration (see - 2251 (fig. 3) - page 65).

This internal crack soon reaches the surface and invariably leads to a break, the pattern of which is very characteristic (see - 2251 (fig. 4) - page 65).

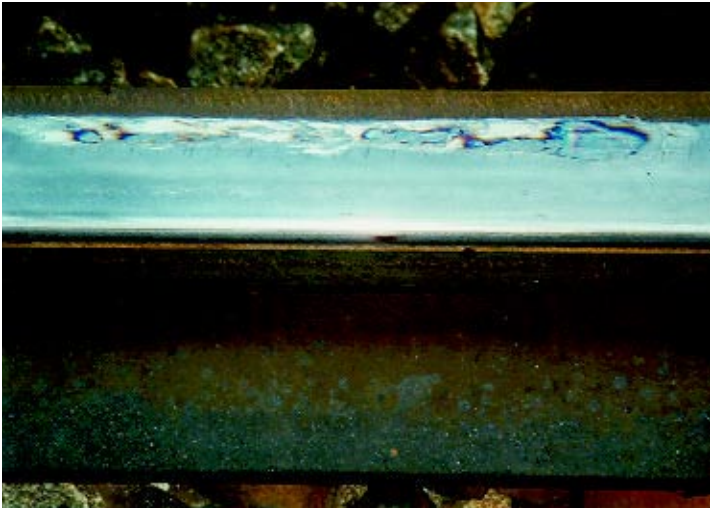
Not to be confused with 211 - page 39, 227 - page 68.

Means of detection:

- visual inspection.

Recommendations:

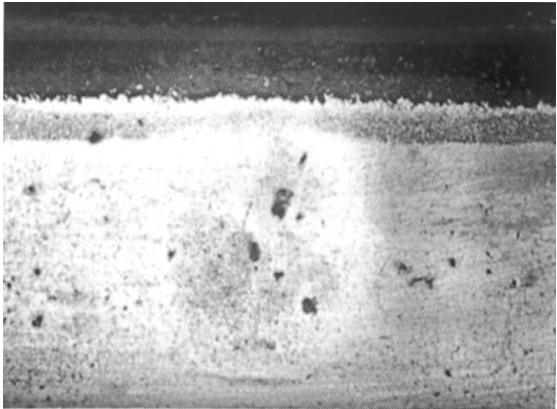
- keep any rail which shows one or more wheel burns without transverse cracking under inspection,
- removal of the rail if defect should prove prejudicial to track maintenance and if the extent or number of burns preclude repair,
- wheel burns can be repaired by resurfacing, depending on their appearance,
- carry out temporary fishplating and remove rails with transverse cracks,
- immediate removal of the broken rail.



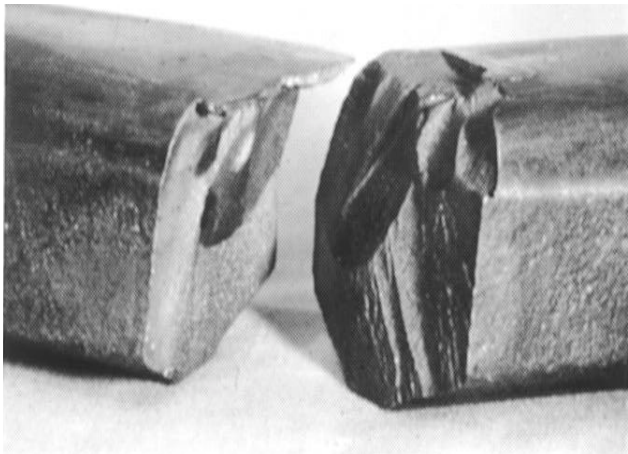
2251 (fig. 1)



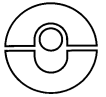
2251 (fig. 2)



2251 (fig. 3)



2251 (fig. 4)



2 Defects away from rail ends

21/22 Head

225 WHEEL BURN

2252 REPEATED WHEEL BURNS

Characteristics and appearance

Defect due to traffic loads.

On sections where wheel-slipping or braking occurs repeatedly, or in places where slipping occurs whilst the tractive unit is on the move, the running surface may assume a characteristic wavy appearance (see - 2252 (fig. 1) - page 67).

This phenomenon may be characterised by the appearance of a series of minute cracks on the running surface, which go deep inside the rail (see - 2252 (fig. 2) - page 67).

These increase the brittleness of the rail appreciably in cold weather, and may cause a break (see - 2252 (fig. 3) - page 67).

This defect is generally encountered in rails located near stop signals.

Means of detection:

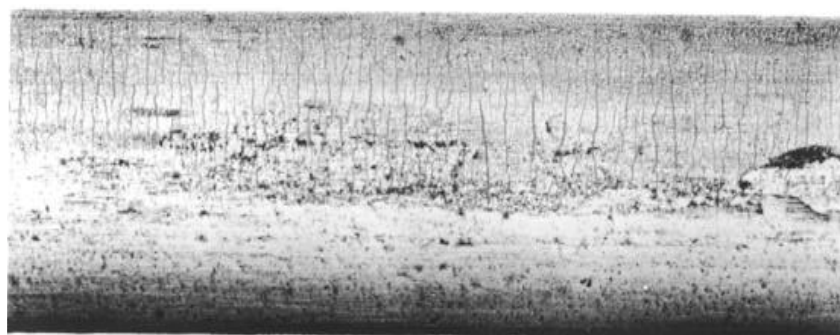
- visual inspection.

Recommendations:

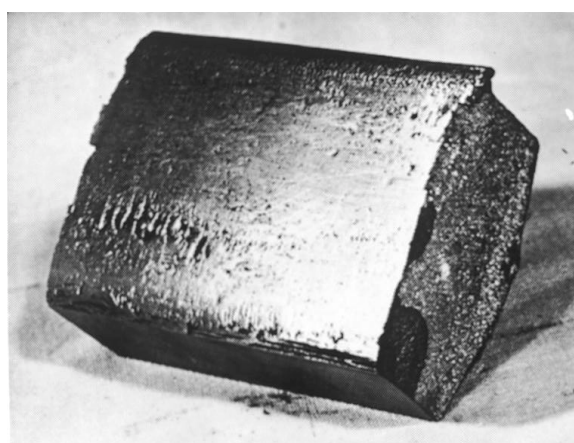
- keep any rail with a wavy appearance (see - 2252 (fig. 1) - page 67) under inspection,
- grind rails with slight wheel burns if necessary,
- remove any rail showing minute cracks extending to the gauge corner near the wheel burn (see - 2252 (fig. 2) - page 67).



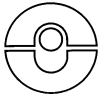
2252 (fig. 1)



2252 (fig. 2)



2252 (fig. 3)



2 Defects away from rail ends

21/22 Head

227 SQUAT / CRACKING AND LOCAL DEPRESSION OF THE RUNNING SURFACE

Characteristics and appearance

This defect is visible on the running surface of the rail head as a widening and a localised depression of the rail/wheel contact band, accompanied by a dark spot containing cracks with a circular arc or V shape (see - 227 (fig. 1) - page 69).

The cracks propagate inside the head, at first at a shallow angle to the surface. Then, when they reach 3 to 5 mm depth, they propagate downward transversely, producing the fracture of the rail (see - 227 (fig. 2 and 3) - page 69).

This defect is often found on flash and aluminothermic welds, also in corrugated zones.

Squats on rails are located randomly and appear numerous, making them dangerous because of risk of multiple fractures with significant gaps.

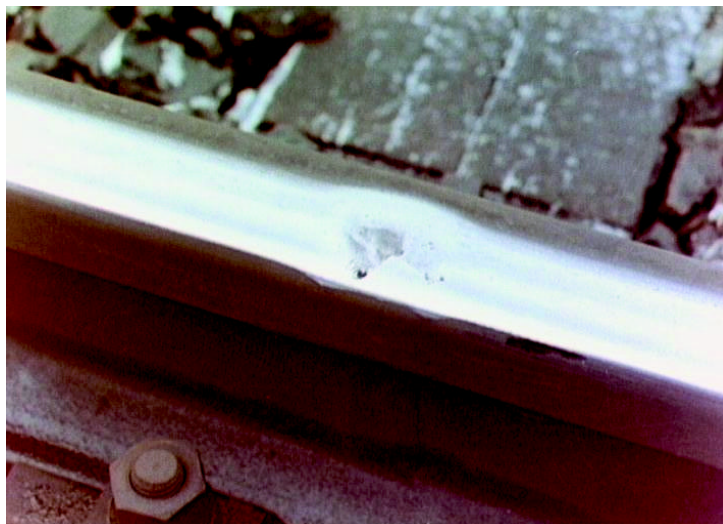
This morphology can be found locally or periodically on the gauge corner of high rails of curves, in zones with Head Checking (see - 2223 (fig. 4) - page 61). In this case, it is codified 2223.

Means of detection:

- visual inspection,
- ultrasonic testing.

Recommendations:

- keep rail under inspection,
- removal of rails showing defects prejudicial to security of quality of the running contact,
- removal of the broken rail.



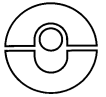
227 (fig. 1)



227 (fig. 2)



227 (fig. 3)



2 Defects away from rail ends

23 Web

232 HORIZONTAL CRACKING

2321 HORIZONTAL CRACKING AT THE WEB-HEAD FILLET RADIUS

Characteristics and appearance

Manufacturing defect.

This crack initially develops parallel to the web-head fillet radius (see - 2321 (fig. 1) - page 71) and may curve either upwards or downwards as it progresses (see - 2321 (fig. 2) - page 71).

In all cases, the crack results in the head breaking away and in fragmentation of the rail, causing a large gap to develop.

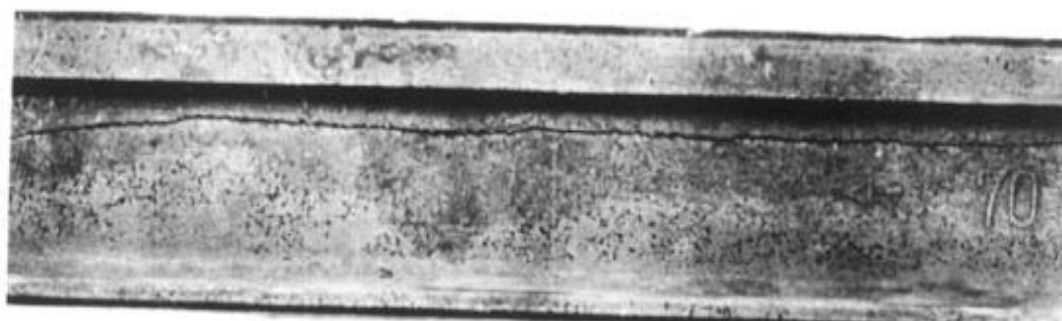
Not to be confused with 236 - page 79.

Means of detection:

- visual inspection,
- ultrasonic testing.

Recommendations:

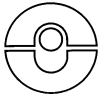
- removal of the cracked rail,
- immediate removal of the cracked rail,
- broken rail: prohibition of traffic and immediate removal of the rail.



2321 (fig. 1)



2321 (fig. 2)



2 Defects away from rail ends

23 Web

232 HORIZONTAL CRACKING

2322 HORIZONTAL CRACKING AT THE WEB-FOOT FILLET RADIUS

Characteristics and appearance

Manufacturing defect.

This crack initially develops parallel to the web-foot fillet radius (see - 2322 (fig. 1) - page 73).

It may curve downwards or upwards as it progresses (see - 2322 (fig. 2) - page 73).

In all cases the crack leads to a break by fragmentation of the rail causing a large gap to develop.

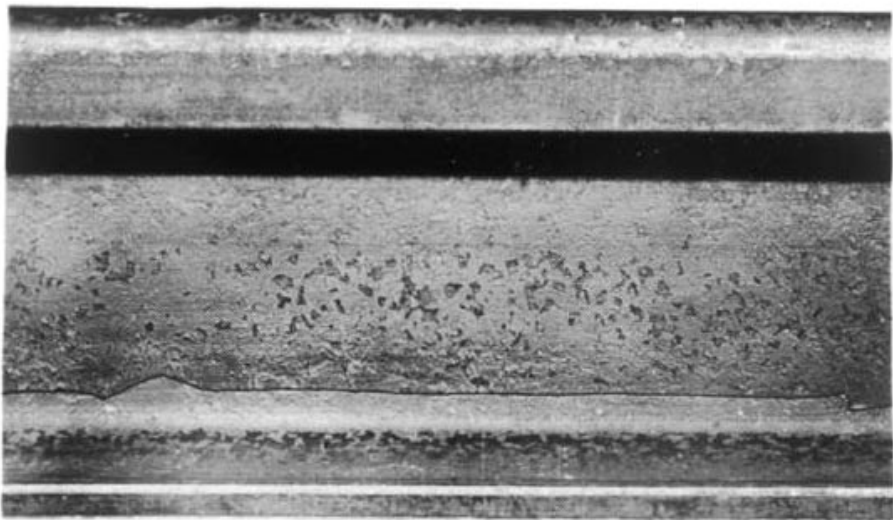
Not to be confused with 236 - page 79.

Means of detection:

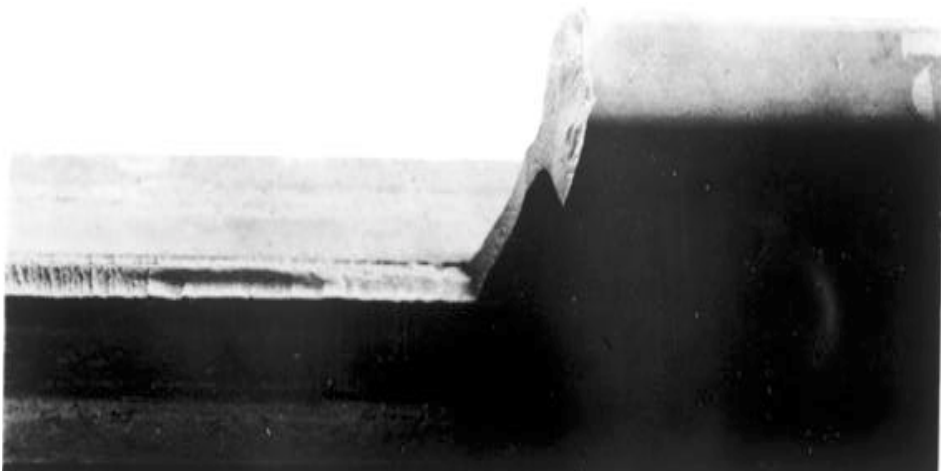
- visual inspection,
- ultrasonic testing.

Recommendations:

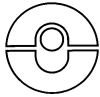
- removal of the cracked rail,
- immediate removal of the cracked rail,
- broken rail: prohibition of traffic and immediate removal of the rail.



2322 (fig. 1)



2322 (fig. 2)



| | |
|----|-----------------------------|
| 2 | Defects away from rail ends |
| 23 | Web |

233 LONGITUDINAL VERTICAL CRACK (PIPING)

Characteristics and appearance

Manufacturing defect.

This defect, commonly known as piping, is characterised by a longitudinal vertical crack in the rail web (see - 233 (fig. 1) - page 75). Combined with another defect or not, it may cause a break to occur.

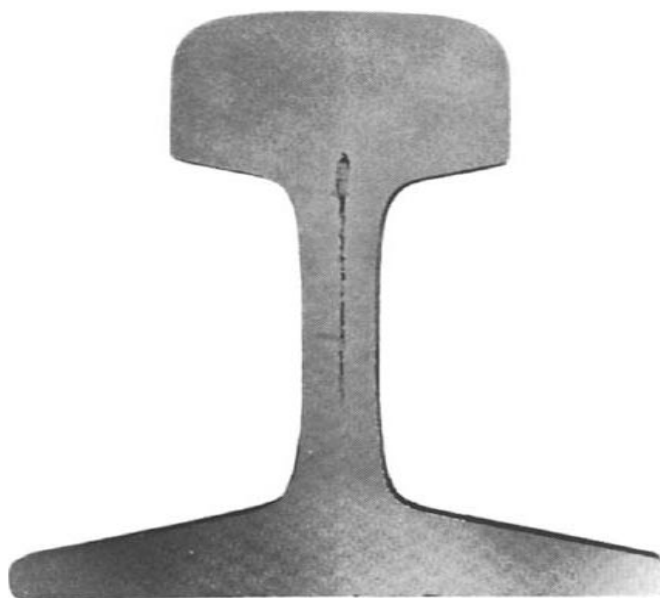
In exceptional cases, swelling on both faces of the web may be observed (see - 233 (fig. 2) - page 75), combined with a slight depression of the running surface at right angles with the defect.

Means of detection:

- visual inspection (swelling of the web),
- ultrasonic testing.

Recommendations:

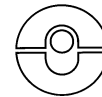
- keep the rail under inspection,
- removal of the rail,
- immediate removal of the rail.



233 (fig. 1)



233 (fig. 2)



2 Defects away from rail ends

23 Web

234 CORROSION

Characteristics and appearance

Defect due to traffic loads.

Extensive corrosion of the rail web may occur in special cases, due to the action of chemical substances in the air or water on particular lines or track sections, especially those in tunnels and on level crossings.

Rust shells break away gradually from the web, the thickness of which decreases steadily.

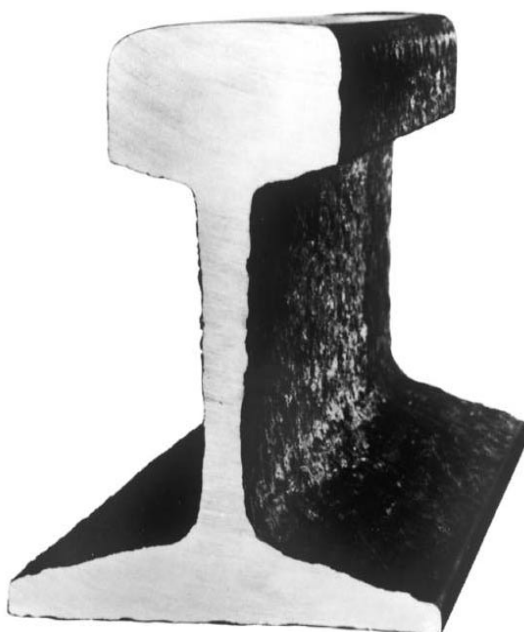
This corrosion in the web may cause the rail to break owing to reduction of the profile. In this case, check that the break is not the result of another defect, particularly 2321 - [page 70](#), 2322 - [page 72](#).

Means of detection:

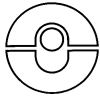
- visual inspection and periodical measurements of web thickness after rust has been cleared away.

Recommendations:

- remove any rail, the web thickness of which has been reduced to an abnormal extent,
- immediate removal of the broken rail.



234



2 Defects away from rail ends

23 Web

235 CRACKING AROUND HOLES OTHER THAN FISHBOLT HOLES

Characteristics and appearance

Defect due to traffic loads.

This defect is characterised by progressive cracks radiating from the edges of holes of a certain diameter bored in the web. The cracks generally develop at an angle of 45° and may cause a break to occur.

The probability of this type of defect forming depends heavily on the quality of drilling.

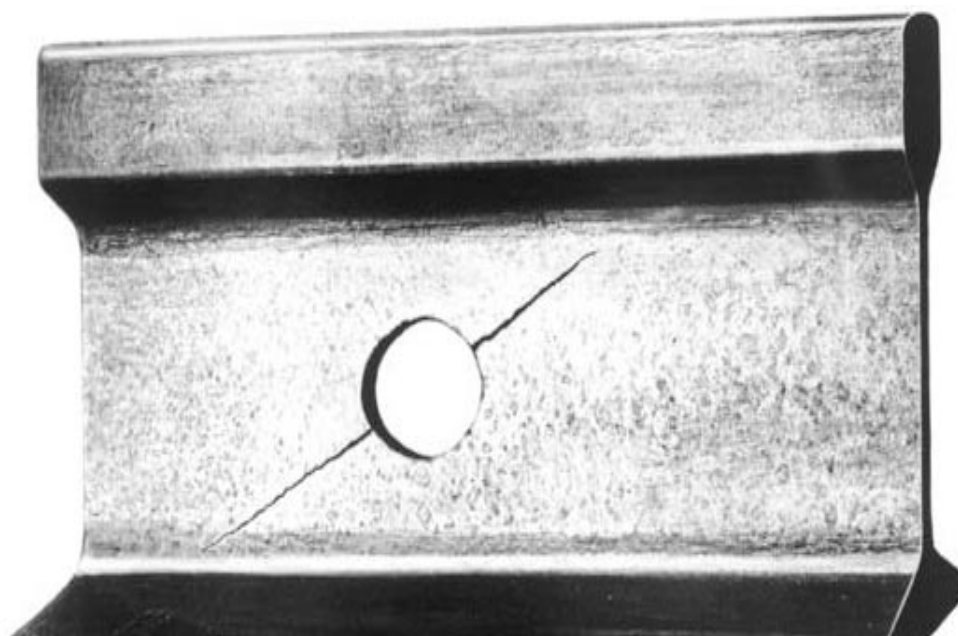
Specific finishing techniques like bevelling and a good drilling surface quality can help to reduce the risk of cracking considerably.

Means of detection:

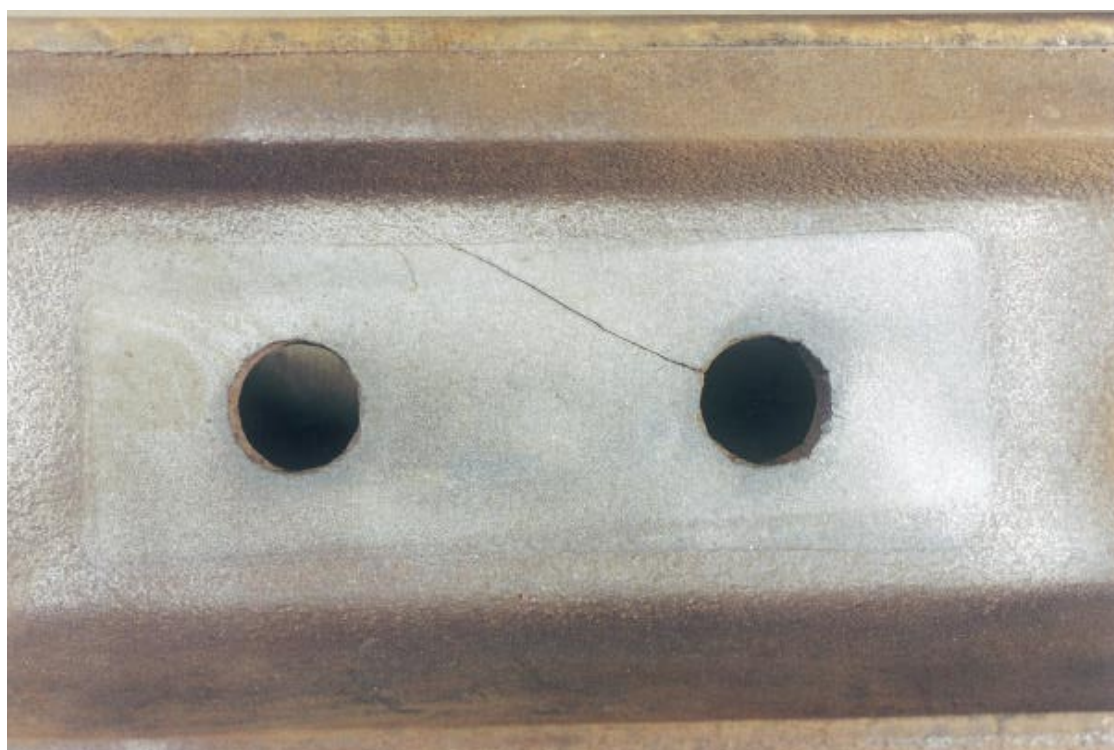
- visual inspection,
- ultrasonic testing.

Recommendations:

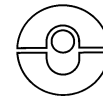
- keep the rail under inspection,
- removal of the rail,
- immediate removal of the rail.



235 (fig. 1)



235 (fig. 2)



2 Defects away from rail ends

23 Web

236 DIAGONAL CRACKING AWAY FROM ANY HOLE

Characteristics and appearance

Manufacturing defect.

These cracks tend to separate the head or foot from the rail web. They can spread locally along the fillet radius, and curve upwards or downwards. They can start from rolling marks.

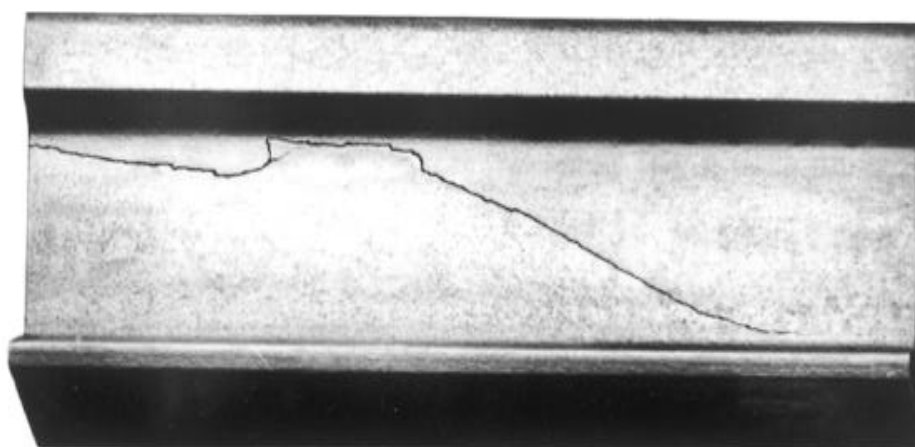
Not to be confused with 2321 - [page 70](#) and 2322 - [page 72](#).

Means of detection:

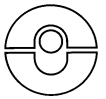
- visual inspection,
- ultrasonic testing.

Recommendations:

- immediate removal of the rail,
- broken rail: prohibition of traffic and immediate removal of the rail.



236



2 Defects away from rail ends

23 Web

239 LAP

Characteristics and appearance

Manufacturing defect.

This extremely rare surface defect is characterised by a line parallel to the axis of rolling on one of the rail surfaces, generally on the web or in the region of the web-head or web-foot fillet radius. It is caused by excess metal folded in during rolling.

All rails from the same cast may be subject to the same defect.

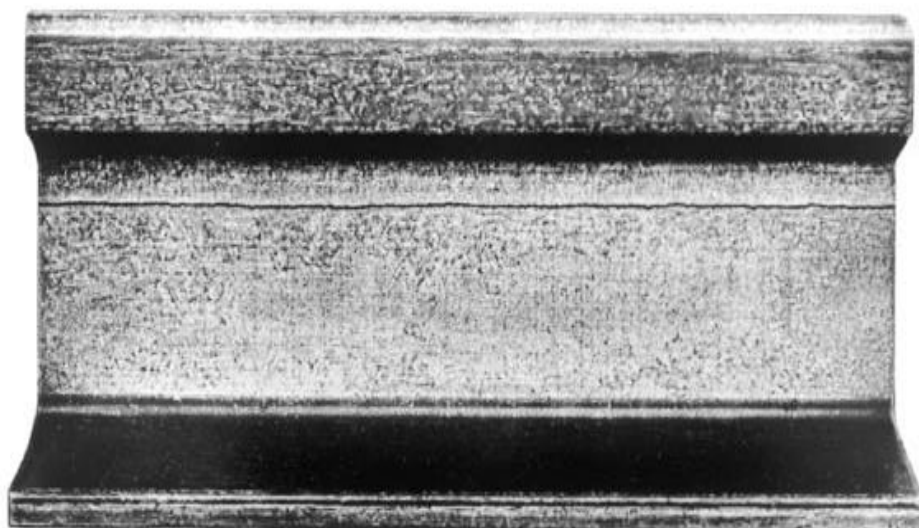
When the line is close to the web-head fillet, check that it is not in fact a longitudinal vertical crack in the head 213 - [page 43](#).

Means of detection:

- visual inspection.

Recommendations:

- keep the rail under inspection and seek expert advice before deciding on the action to be taken.



239



| | |
|----|-----------------------------|
| 2 | Defects away from rail ends |
| 25 | Foot |

253 LONGITUDINAL VERTICAL CRACKING

Characteristics and appearance

Manufacturing defect.

Small longitudinal lines, which occurred during rolling and are located in the middle portion of the underside of the foot, develop into cracks due to traffic loads. These cracks ultimately cause sudden breakage of the rail, generally during cold weather.

The break is generally very oblique, particularly in the web and the longitudinal crack at the origin of it can easily be detected after breakage has occurred. This defect can develop in several parts of the same rail and result in the formation of an extensive gap due to multiple breaks.

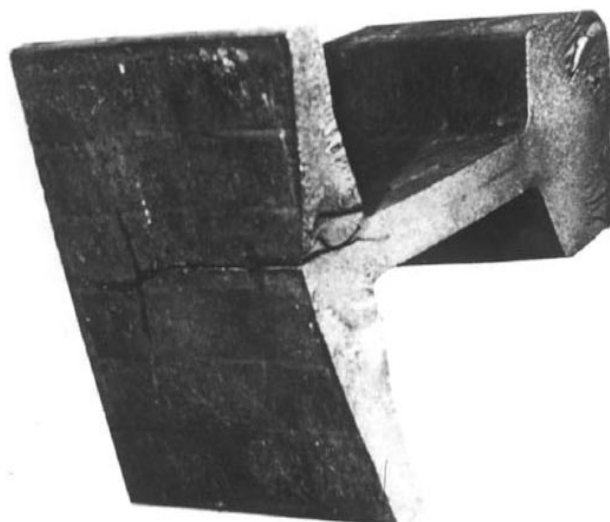
This defect may take the form of an epidemic in rails from the same cast.

Means of detection:

- visual inspection.

Recommendations:

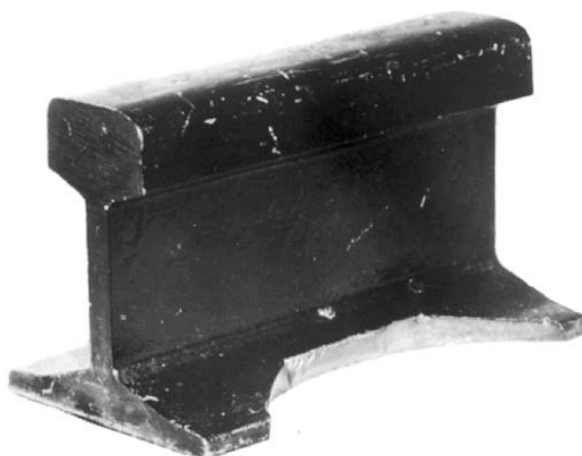
- immediate removal of the rail.



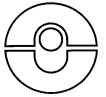
253 (fig. 1)



253 (fig. 2)



253 (fig. 3)



2 Defects away from rail ends

25 Foot

254 CORROSION

Characteristics and appearance

Defect due to traffic loads.

Extensive corrosion of the rail foot may occur in specific cases, due to the action of chemical substance in air and water, on particular lines or track sections, especially in some tunnels and on some level crossings. It can also be electrochemical in nature.

Rust shells break away gradually from the foot, the thickness of which decreases steadily (see - 254.1 (fig. 1 and 2) - [page 84](#)).

This corrosion in the foot may result in a break due to profile reduction. Check in such cases that the break has not been caused by another defect, particularly 2322 - [page 72](#).

A further type of break originates in a small endurance crack located in the underside of the foot. This particular break, which is crescent-shaped and radiates from an etch pit ([see - 254.2 - page 84](#)) occurs suddenly.

Means of detection:

- visual inspection.

Recommendations:

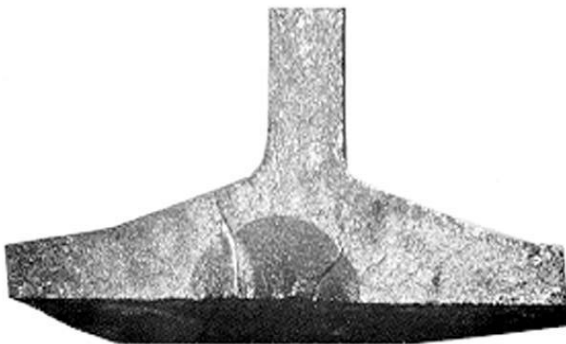
- remove any rail with a foot abnormally reduced in size,
- immediate removal of the broken rail.



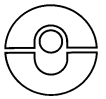
254.1 (fig. 1)



254.1 (fig. 2)



254.2



3 Defects caused by rail damage

30 Full section

301 BRUISING

Characteristics and appearance

Defects due to traffic loads.

These defects result from accidental impacts of various origins:

- derailments,
- dragging parts of vehicles,
- damaged tyres,
- handling operations,
- improper use of tools such as steel hammers (see - 301 (fig. 1) - page 86) and flat chisels to remove electrical connections, etc.,
- arcing (see - 301 (fig. 2) - page 86),
- ballast imprints (see - 301 (fig. 3) - page 87),
- incrustation of a foreign body in the tyre causing an imprint which is repeated at intervals (see - 301 (fig. 4) - page 87),
- materials falling from trains.

When the bruise has a sharp profile, it can have a notch effect and be at the origin of cracks and breaks, particularly on hard-steel rails.

Bruising caused by damaged tyres generally results from the incrustation of hard scrap in these tyres. There follows deterioration of the running surface through crushing. Such bruising may occur at regular intervals on several consecutive rails of the same stretch, sometimes over a considerable distance. In the long run, these bruises develop into horizontal cracks a few millimetres below the surface, subsequently accompanied by local depressions in the running surface. Such cracks may curve downwards and result in breakages.

Not to be confused with 221.1 - page 53 or 2251 - page 64.

Bruising occurring during handling operations may take the form more particularly of deep scratchiness on the running surface or on the underside of the rail foot.

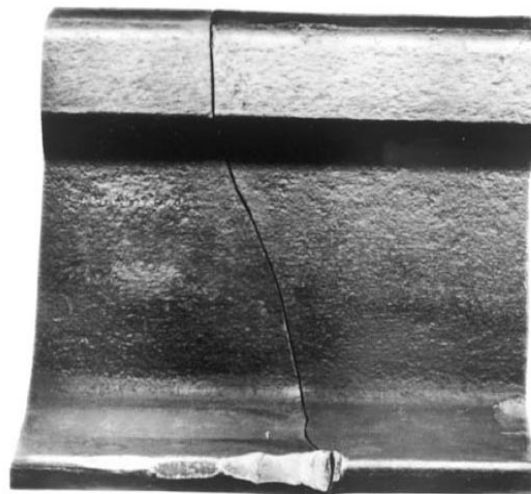
Bruising through arcing from traction return current generally results in the formation of one or more craters under the rail foot. Such bruising may also be the cause of breakages, by their nature sudden (see - 301 (fig. 2) - page 86 - view of rail-foot underside).

Means of detection:

- visual inspection.

Recommendations:

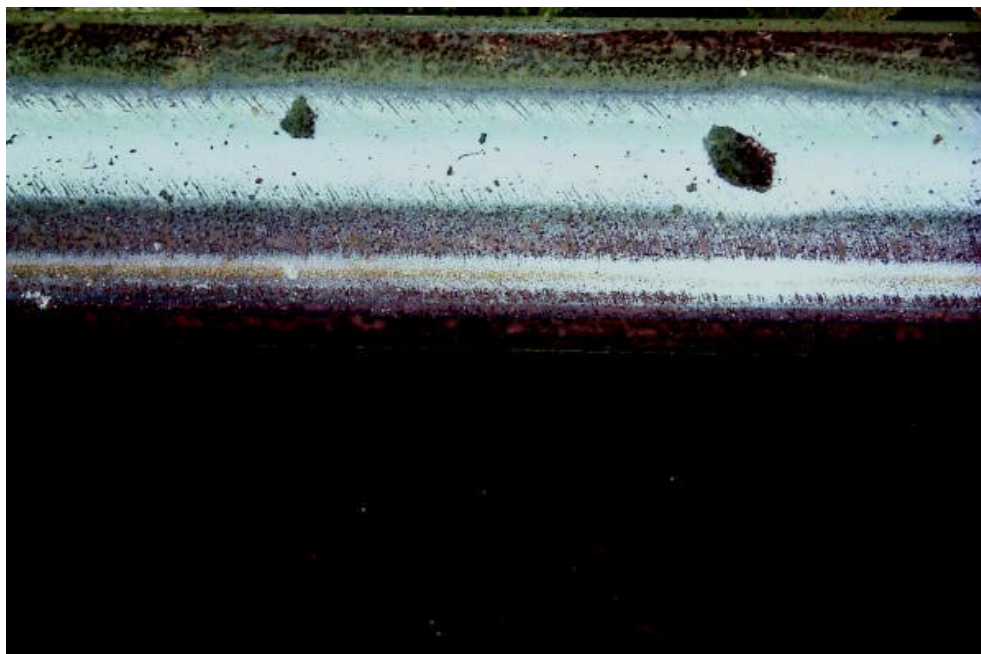
- check the extent of the area affected,
- keep the rails under inspection,
- removal of the cracked rail,
- immediate removal of the broken rail,
- certain bruises on the running surface may be repaired by resurfacing or eliminated by grinding.



301 (fig. 1)



301 (fig. 2)



301 (fig. 3)



301 (fig. 4)



| | |
|----|-------------------------------|
| 3 | Defects caused by rail damage |
| 30 | Full section |

302 **FAULTY MACHINING**

Characteristics and appearance

Defect due to traffic loads.

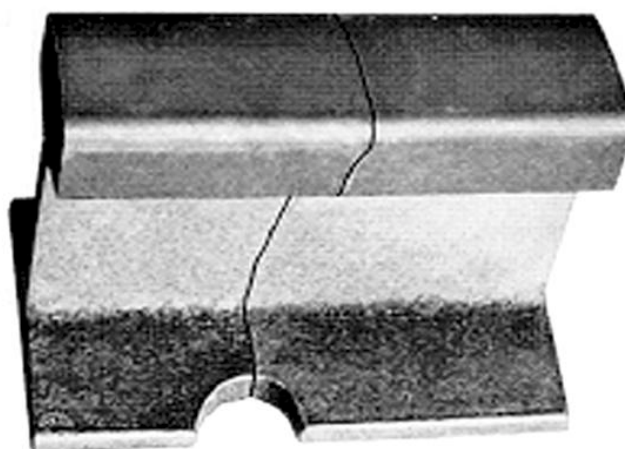
Improper in-track drilling (see - 302 (fig. 1) - page 89) of foot or web of rail; faulty cutting or use of an unsuitable technique (a flame-cutter for example (see - 302 (fig. 2 and 3) - page 89); drilling of twin fishbolt holes or other non-acceptable machining, generally lead to cracking and breakage of the rail either by notch effect or profile reduction.

Means of detection:

- visual inspection,
- ultrasonic testing.

Recommendations:

- removal of the rail,
- immediate removal of the rail.



302 (fig. 1)



302 (fig. 2)



302 (fig. 3)



| | |
|----|-------------------------------|
| 3 | Defects caused by rail damage |
| 30 | Full section |

303 PERMANENT DEFORMATION (WARPED RAIL)

Characteristics and appearance

Permanent rail deformations through accidents, derailments, faulty handling or other external causes generally do not constitute defects as such.

They foul the track alignment and may be the origin of other defects due to increased in-track stresses.

Means of detection:

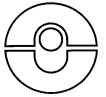
- visual inspection and measurement of deformations.

Recommendations:

- removal of the rail,
- immediate removal of the rail.



303



4 Welding and resurfacing defects

41 Electric flash-butt welding

411 TRANSVERSE CRACKING OF THE PROFILE

Characteristics and appearance

Cracking develops in the weld cross-section either from an internal defect of the head in the weld (see - 411.1 - page 92), or from a defect located in the foot of the rail (see - 411.2 - page 92). It ultimately leads to complete breakage of the section.

The pattern of the breakage is characterised either by a smooth and bright spot in the head (411.1) or by a dark spot on the foot (411.2).

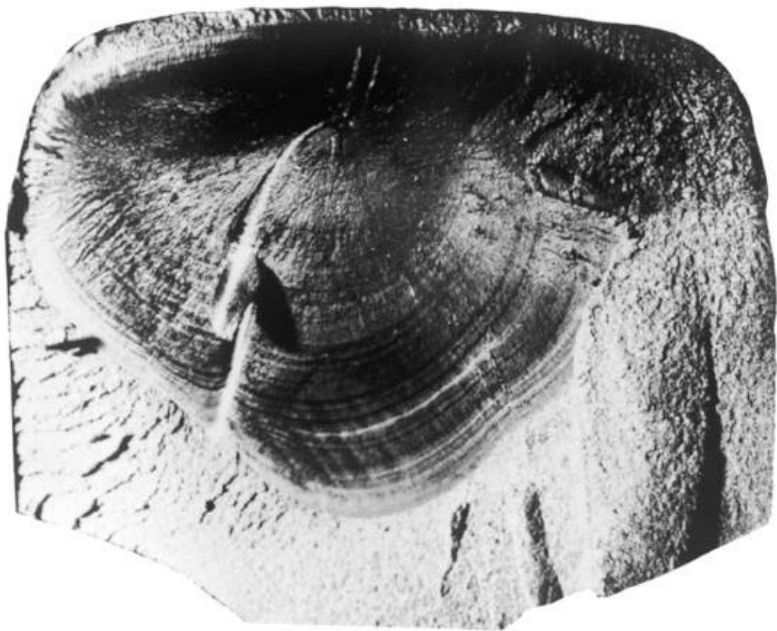
Means of detection:

- visual inspection,
- ultrasonic testing.

Recommendations:

- keep defect under inspection,
- carry out temporary fishplating,
- immediate removal of the rail,
- carry out temporary fishplating and remove the broken weld immediately by laying a new section.

However, repair the cracked or broken weld by welding whenever this is possible (crack or break located in a plane close to a normal cross-section of the profile).



411.1



411.2



4 Welding and resurfacing defects

41 Electric flash-butt welding

412 HORIZONTAL CRACKING OF THE WEB

Characteristics and appearance

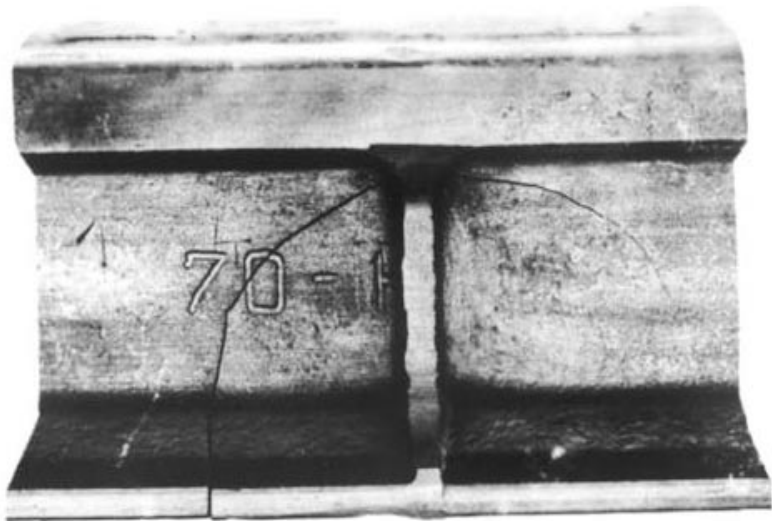
This defect develops across the weld and generally assumes a curved shape in the web. As it spreads, it may curve downwards (see - 412.1 - page 94) or upwards (see - 412.2 - page 94), or simultaneously in both directions (see - 412.3 - page 94). It ultimately leads to breakage of the rail near the weld.

Means of detection:

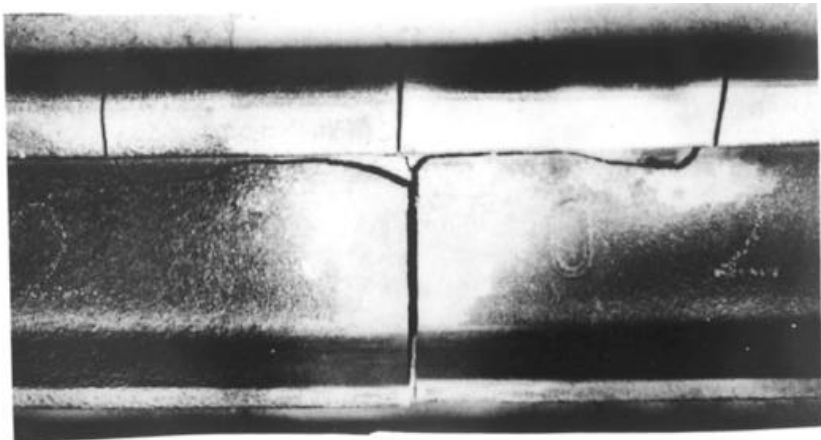
- visual inspection,
- ultrasonic testing.

Recommendations:

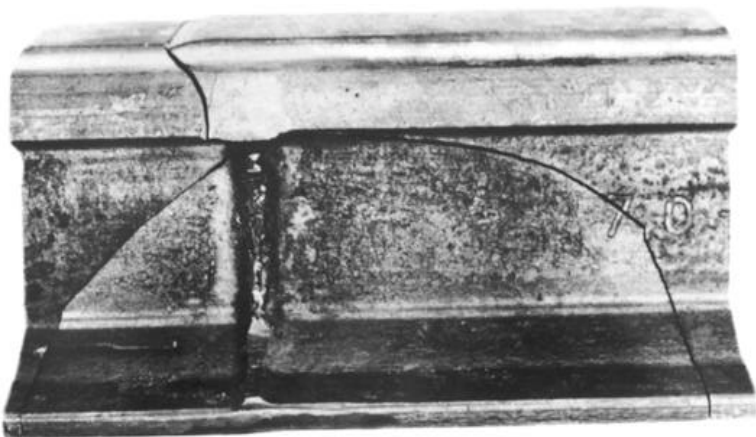
- removal of the cracked weld immediately by laying a new section,
- prohibition of traffic and immediate removal of the broken weld by laying a new section,



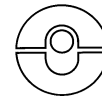
412.1



412.2



412.3



4 Welding and resurfacing defects

42 Thermit welding

421 TRANSVERSE CRACKING OF THE PROFILE

Characteristics and appearance

This defect develops along a plane near a normal cross-section of the profile.

It ultimately leads to breakage of the profile.

Some of the characteristics of this defect are given below:

- crack originating in the flange under the foot and developing along a transverse plane in adjacent rails (see - 421.1 - page 96);
- crack located largely in the vertical plane of the weld (see - 421.2 - page 96);
- crack located in a vertical plane near the weld (see - 421.3 - page 96).

Means of detection:

- visual inspection,
- ultrasonic testing.

Recommendations:

- keep defect under inspection,
- carry out temporary fishplating,
- immediate removal of the rail,
- carry out temporary fishplating and eliminate defect by laying a new section.

However, repair the cracked or broken weld by welding whenever this is possible (crack or break located in a plane very close to a normal cross-section of the profile).



421.1



421.2 (fig. 1)



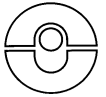
421.2 (fig. 2)



421.2 (fig. 3)



421.3



4 Welding and resurfacing defects

42 Thermit welding

422 HORIZONTAL CRACKING OF THE WEB

Characteristics and appearance

This defect is generally found in welded rails where the rail ends have not been cut off before welding.

This crack, which generally links up the fishbolt holes across the weld (see - 422.1 (fig. 1) - page 98), can spread to the foot or head of adjacent rails and lead to breakage.

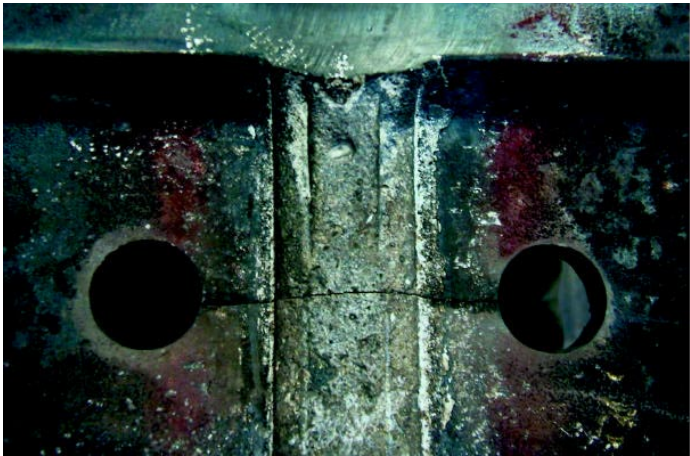
It may also be found, although much less frequently, in welds of non-drilled rails (see - 422.2 - page 98). In such cases, it can develop from a small crack in a vertical flange, and also lead to breakage.

Means of detection:

- visual inspection,
- ultrasonic testing.

Recommendations:

- immediate removal of the cracked weld by laying a new section,
- prohibition of traffic and immediate removal of the broken weld by laying a new section.



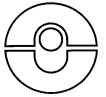
422.1 (fig. 1)



422.1 (fig. 2)



422.2



4 Welding and resurfacing defects

43 Electric arc welding

431 TRANSVERSE CRACKING OF THE PROFILE

Characteristics and appearance

This defect may occur in weldings performed with or without forging of the foot.

Cracking generally develops at the periphery of the welding. It ultimately leads to breakage of the profile.

The breakage area is generally identified by a dark spot characteristic of a fatigue crack originating in a weld defect (inclusions, porosity, etc.).

Not to be confused with sudden arcing near the weld (see - 301 - page 85).

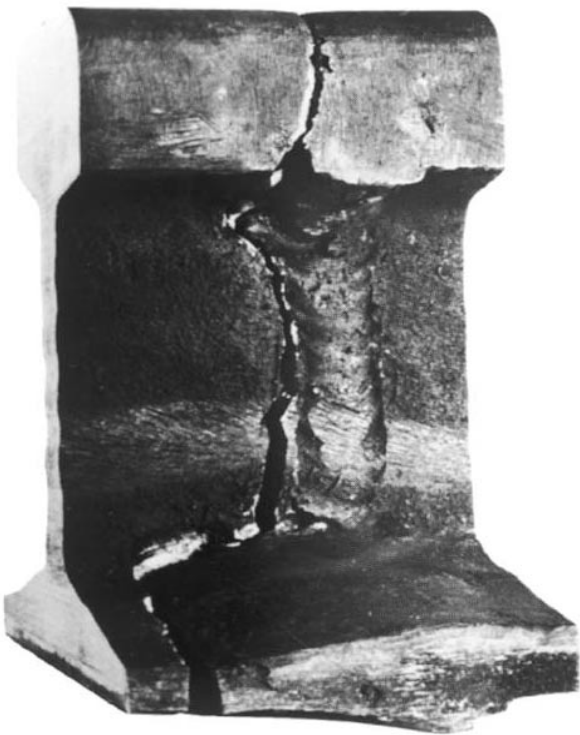
Means of detection:

- visual inspection,
- ultrasonic testing, confirmed if need be by local checking.

Recommendations:

- keep defect under inspection,
- carry out temporary fishplating,
- immediate removal of the rail,
- carry out temporary fishplating and remove the broken weld immediately by laying a new section.

However, whenever feasible a cracked or broken weld should be repaired by welding, providing welding has been performed without forging of the foot (crack or break located in a plane very close to a normal cross-section of the profile).



431

4 Welding and resurfacing defects

43 Electric arc welding

432 HORIZONTAL CRACKING OF THE WEB

Characteristics and appearance

This defect is generally found on welded rails where the rail ends have not been cut off before welding.

Cracking, which generally links up the fishbolt holes across the weld, may spread to the foot or head of the adjacent rails and lead to breakage.

Means of detection:

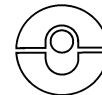
- visual inspection,
- ultrasonic testing.

Recommendations:

- immediate removal of the cracked weld by laying a new section,
- prohibition of traffic and immediate removal of the broken weld by laying a new section.



432



4 Welding and resurfacing defects

47 Resurfacing

471 TRANSVERSE CRACKING OF THE RAIL HEAD

Characteristics and appearance

This transverse fatigue cracking across the resurfaced part originates in a nucleus generally located at the base of the weld deposit. This nucleus may be an inclusion, a local discontinuity due to welder instability, or a flake due to improper stoving. It may also start on an end-bead crater or on shrinking cracks. As it develops, the cracking leads ultimately to breakage of the rail. The breakage is characterised by a smooth, shiny patch originating in the deposit metal.

Not to be confused with 211 - [page 39](#) or 2251 - [page 64](#).

Means of detection:

- visual inspection,
- ultrasonic testing.

Recommendations:

Depending on the degree of the defect(s):

- keep defect under inspection,
- carry out temporary fishplating,
- removal of the rail,
- immediate removal of the broken rail.



471 (fig. 1)



471 (fig. 2)



| | |
|----|---------------------------------|
| 4 | Welding and resurfacing defects |
| 47 | Resurfacing |

472 DETACHMENT OR SHELLING OF THE RESURFACED PORTION

Characteristics and appearance

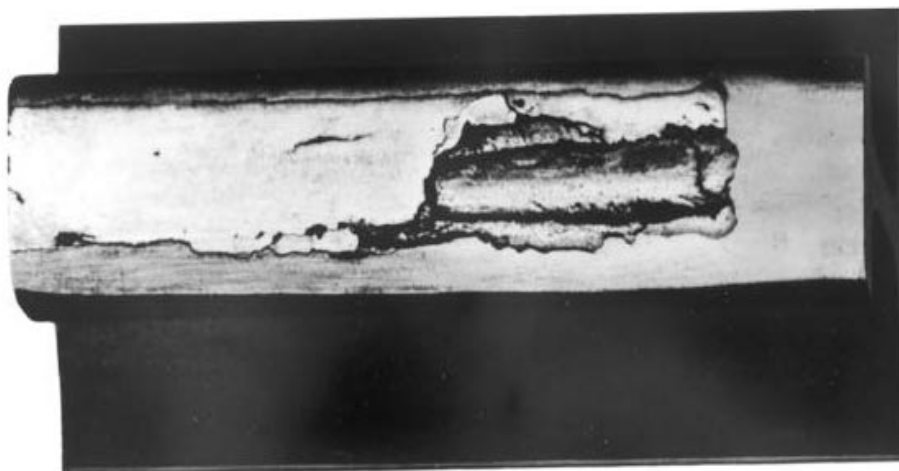
The crack, which may lead to breakage of the rail, generally develops from weld metal/parent metal binding defects, or from other welding defects (porosity, inclusions, shrinking cracks, crater cracks, etc.).

Means of detection:

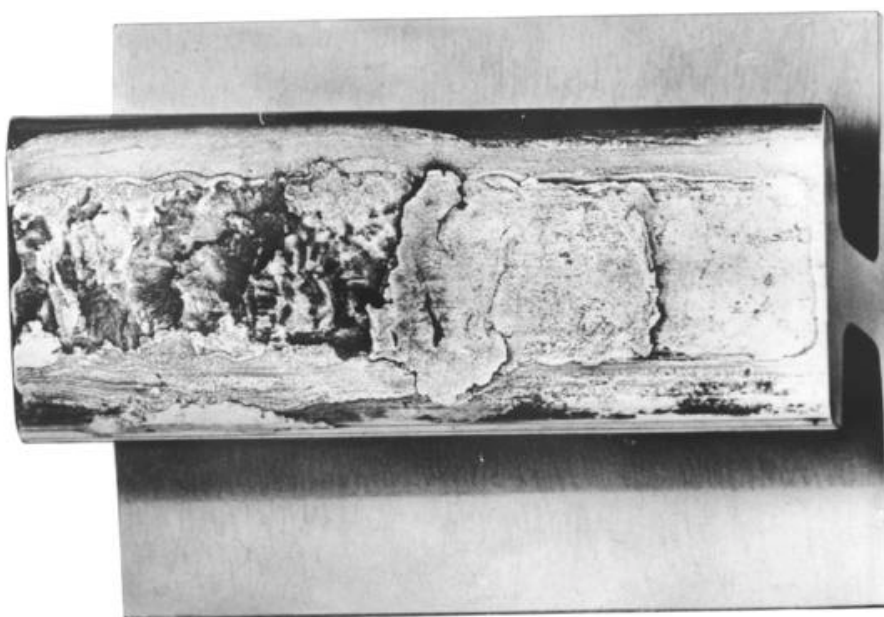
- visual inspection,
- ultrasonic testing.

Recommendations:

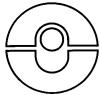
- any detachment or shelling of the resurfaced portion may be repaired by fresh resurfacing after elimination of the defect down to the parent metal,
- when such repair is not possible, immediate removal of the rail.



472 (fig. 1)



472 (fig. 2)



| | |
|----|---------------------------------|
| 4 | Welding and resurfacing defects |
| 48 | Other welding methods |

481 TRANSVERSE CRACKING UNDER ELECTRICAL CONNECTION

Characteristics and appearance

Progressive transverse cracking originating on the outer face of rail head (see - 481.1 - page 107) on one of the web faces (see - 481.2 - page 107) or on one of the flanges of the foot (see - 481.3 - page 107) at right angles with an electrical connection for return current.

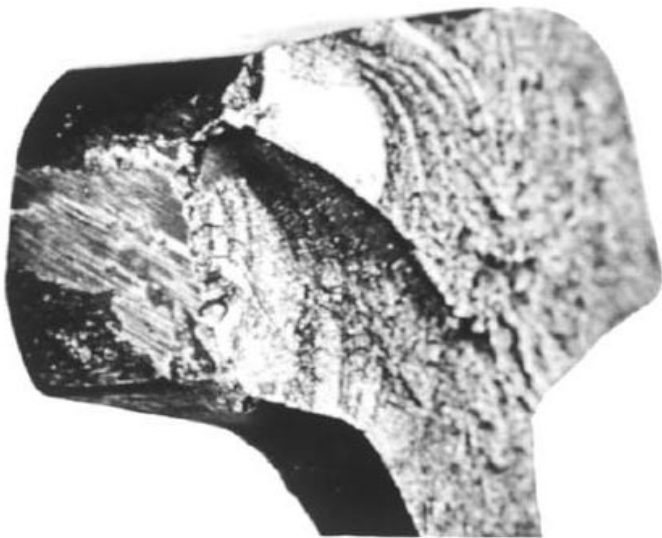
The progression of this crack may ultimately lead to breakage of the rail.

Means of detection:

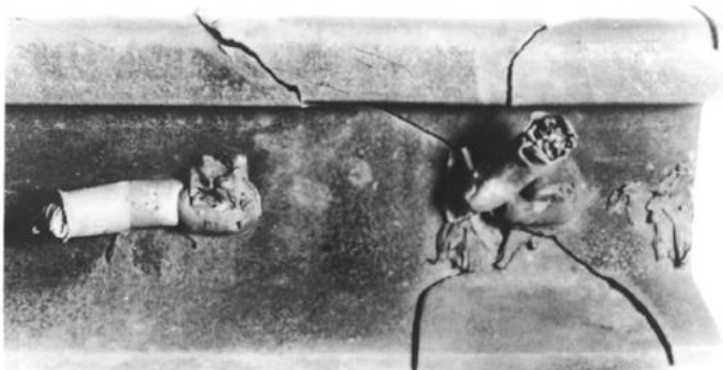
- visual inspection,
- ultrasonic testing for head and web cracks.

Recommendations:

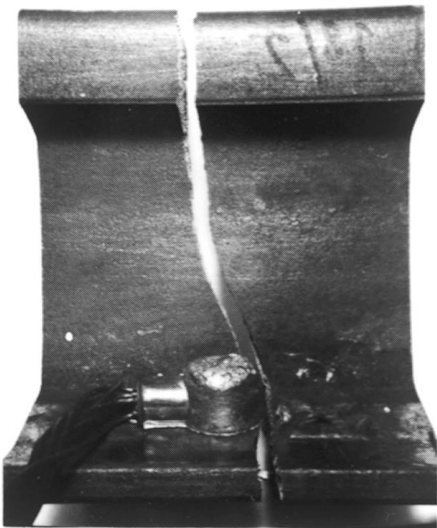
- immediate removal of the rail.



481.1



481.2



481.3