BS EN 17397-1:2020



BSI Standards Publication

Railway applications — Rail defects

Part 1: Rail defect management

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National foreword

This British Standard is the UK implementation of EN 17397-1:2020.

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Contents

Page

European foreword ... 3
1 Scope ... 4
2 Normative references ... 4
3 Terms and definitions ... 4
4 Abbreviations ... 7
5 Defect management system ... 7
5.1 General ... 7
5.2 Defect types ... 7
5.3 NDT inspection of rails ... 7
5.4 Management of NDT inspection results ... 8
6 Limits of rail condition ... 8
6.1 General ... 8
6.2 Definition of limits ... 8
6.3 Rail defect immediate action limits L_{IA} ... 10
7 Risk mitigation ... 10
Annex A (informative) Description of rail defects ... 11
A.1 Definition and description of rail defects ... 11
A.2 Characterization of rail defects ... 15
A.2.1 Transverse cracking ... 15
A.2.2 Horizontal cracking ... 19
A.2.3 Longitudinal vertical cracking ... 25
A.2.4 Squat ... 29
A.2.5 Head checks ... 33
A.2.6 Other rail head surface conditions ... 35
A.2.7 Corrosion ... 50
A.2.8 Wear ... 54
A.2.9 Other rail defects ... 59
Annex B (informative) Immediate action limits L_{IA} ... 67
Bibliography ... 69

Documents
Document Sharing Hub
Full document details: BS EN 17397-1:2020

European foreword

This document (EN 17397-1:2020) has been prepared by Technical Committee CEN/TC 256 “Railway applications”, the secretariat of which is held by DIN.

This European Standard shall be given the status of a national standard, either by publication of an identical text or by endorsement, at the latest by May 2021, and conflicting national standards shall be withdrawn at the latest by May 2021.

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1 Scope

This document specifies the defect management system the infrastructure manager uses to control the risk of severe accidents due to degradation of internal or surface defects on rails complying with EN 13674-1, EN 13674-2, EN 13674-4 and EN 15689:2009 (excluding grooved rails EN 14811 — which need alternative systems).

2 Normative references

The following documents are referred to in the text in such a way that some or all of their content constitutes requirements of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

EN 16729-3:2018, *Railway applications - Infrastructure - Non-destructive testing on rails in track - Part 3: Requirements for identifying internal and surface rail defects*

3 Terms and definitions

For the purposes of this document, the following terms and definitions apply.

ISO and IEC maintain terminological databases for use in standardization at the following addresses:

— IEC Electropedia: available at http://www.electropedia.org/

— ISO Online browsing platform: available at https://www.iso.org/obp

3.1
plain rail
zone comprising all parts of the rail located away from the rail ends and the welding zones

3.2
rail end
part of the rail located within the length of the fishplates

3.3
welding zone
weld material itself plus 20 mm from each end of the weld collar (for aluminothermic welding and electric arc welding) or upset (flash-butt welding)

Note 1 to entry: Any defect occurring in this zone is classified as a welding defect.

3.4
defective rail
rail which, for reasons of integrity or profile (including wear), requires management (examples in Annex A)

3.5
damaged rail
rail which is neither cracked nor broken, but which has other defects

3.6
cracked area
part of the rail with a localized material discontinuity

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3.7
broken rail
rail which has separated into two or more pieces (see Figure 1 and Figure 2) or any rail from which a piece of metal becomes detached from the rail head, with a gap of more than 50 mm in length and more than 10 mm in depth resulting in a running band less than 30 mm in width (see Figure 3)

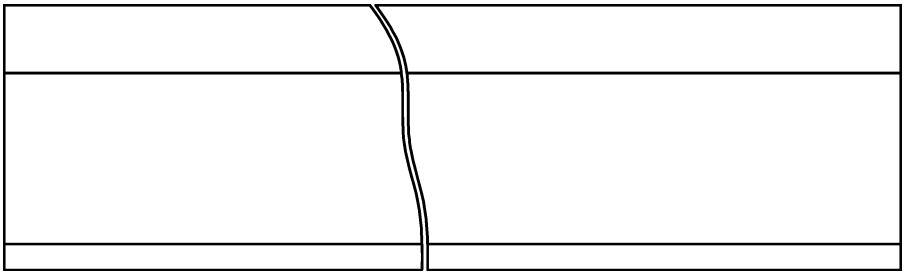
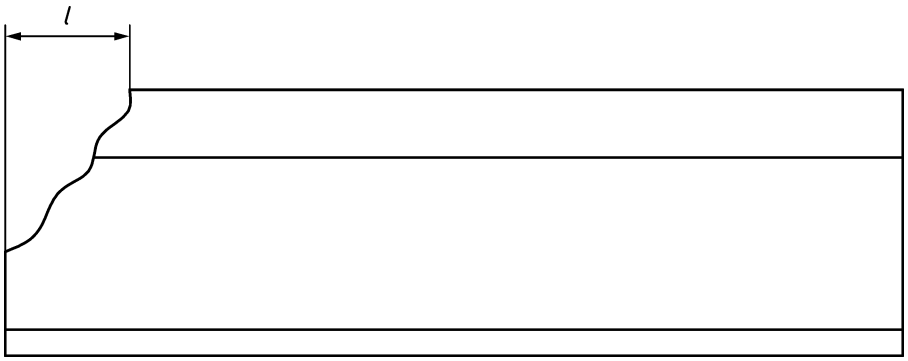
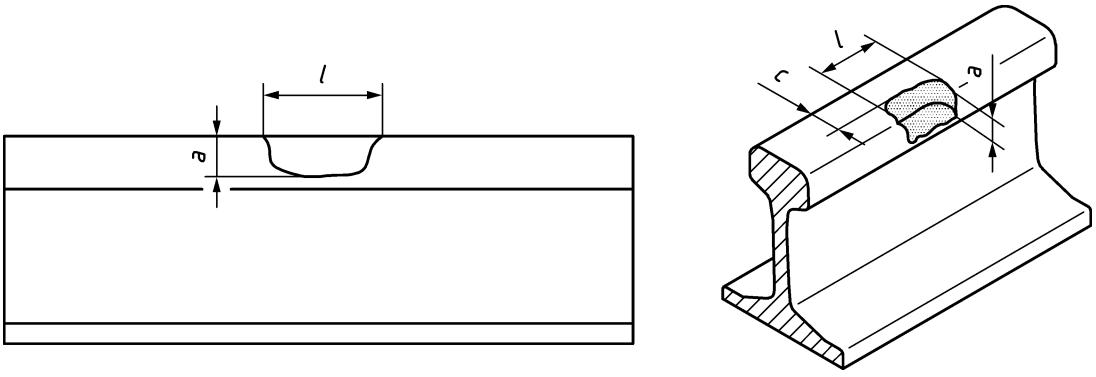


Figure 1 — Example of a broken rail separated in two pieces



Key
l horizontal length

Figure 2 — Example of a broken rail with a gap at the rail end



Key
a vertical depth
l horizontal length
c non-cracked area

Figure 3 — Example of a broken rail with a gap

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3.8
rail surface defect
defect which initiates on any of the surfaces of the rail

3.9
rail head surface defect
defect which initiates on or within 5 mm from the running surface of the rail

3.10
rail internal defect
defect which initiates from within the rail section but may grow to become visible on the rail surface

3.11
NDT Method
discipline applying a physical principle in non-destructive testing

[SOURCE: EN 13938-5:2004, definition 3.2]

EXAMPLE: Ultrasonic testing.

3.12
wheel/rail interaction
effect of rolling and sliding contact and direct forces from the vehicle wheels which can cause damage to the rail

3.13
environmental degradation
damage to the rail caused by external environmental factors

3.14
geometrical planes of the rail
see EN 16729-3:2018, 3.10, Figure 4

3.15
infrastructure manager [IM]
body or organisation responsible in particular for establishing and maintaining railway infrastructure, as well as for operating the control and safety systems

3.16
track maintenance engineer [TME]
engineer with “safety of line” responsibility for a defined track area

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4 Abbreviations

For the purposes of this document, the following abbreviations apply.

Abbreviation	Definition
RDM	rail defect management
S&C	switches and crossings
TME	track maintenance engineer
IM	infrastructure manager
NDT	non-destructive testing
CWR	continuously welded rail
RAMS	reliability, availability, maintainability, safety
LCC	life cycle costs

5 Defect management system

5.1 General

An infrastructure manager shall put a framework in place to monitor the condition of its assets. If the infrastructure becomes deteriorated, it needs to be renewed or repaired. This can be for economic reasons or, typically at a later state in the development and propagation of the defect, due to safety reasons.

5.2 Defect types

There are a wide variety of rail defects that lead to damaged or defective rail. These defects can be grouped and categorized by a system.

The classification of the defect types along with the internationally widely used numbering scheme can be found in the Annex A of this document.

5.3 NDT inspection of rails

The IM shall implement a testing framework (appropriate NDT methods and inspection frequencies) to inspect rail to detect the defects considered relevant by the IM. The testing frequency should be designed to mitigate the risk that a detectable defect propagates to a critical size leading to failure.

The standard EN 16729-3:2018 describes how several of the most relevant defects can be detected using various methods of NDT.

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5.4 Management of NDT inspection results

Actions shall be taken depending on the results of the inspection. Several limits can exist that lead to different actions. Immediate action has to be taken, if the defect has reached a safety critical size. Smaller detected defects shall be managed (by repair or removal) to prevent them from reaching a safety critical size.

The infrastructure manager shall record the lifecycle of each defect from detection, monitoring, to removal.

6 Limits of rail condition

6.1 General

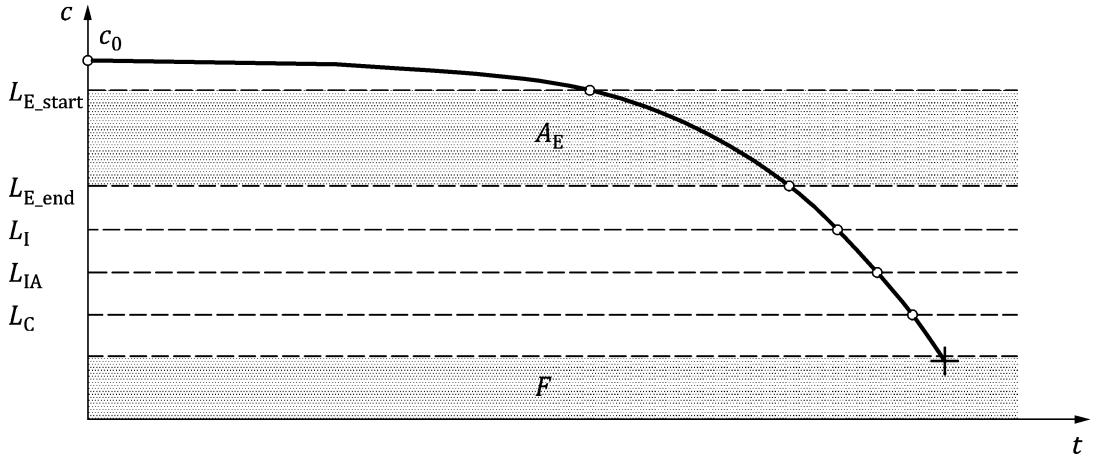
A methodology to analyse rail condition should take into account the economic optimum of reliability, availability, maintainability, safety (RAMS) and life cycle costs (LCC). Different infrastructure managers have different limits for these economic factors, based on various boundary conditions.

The larger a defect grows, the greater becomes the safety risk and this has to be balanced against the economic limits. The urgent removal of a safety critical defect is usually not the most cost-effective action with regards to LCC.

6.2 Definition of limits

A typical degradation curve is shown in Figure 4, together with an example of various limits for intervention.

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Key

C	Current condition of the rail
C_0	Basic condition, this is the condition at which new rail is accepted after the installation in track. Due to the constant usage of the rail, the condition starts to deteriorate.
L_{E_start}	Start of economic maintenance limit, when reaching or exceeding the limit L_{E_start} actions such as rail reprofiling or repair welding can be considered to improve the condition of the rail and extend its service live.
L_{E_end}	End of economic maintenance limit, at this condition the economic maintenance of the rail has been expended. Actions to improve the condition of the rail are no longer feasible. Further use of the rail is possible. Planning of rail replacement is advised to avoid that the rail reaches a critical condition.
L_I	Intervention limit, intervention limit refers to the value which, if exceeded, requires corrective maintenance in order that the immediate action limit shall not be reached before the next inspection.
L_{IA}	Immediate action limit, the condition of the rail has reached the limit of concern with regard to the structural integrity of the rail. The condition considers an operational risk and the rail does no longer allow for safe and unlimited traffic. Corrective maintenance actions shall be executed as soon as practical, normally within a fixed time limit set by the IM. In the meantime, temporary measures shall be considered to mitigate the risks until the rail can be replaced.
L_C	Critical limit, rail of this condition is a high risk and rail traffic shall be suspended immediately until a full risk assessment has been undertaken by the track maintenance engineer or the rail has been repaired or replaced.
F	Failure of the rail (e.g. rupture)
A_E	Area of economic maintenance
t	Time

Figure 4 — Degradation curve of the rail over the service life

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6.3 Rail defect immediate action limits L_{IA}

Informative immediate action limits L_{IA} for the most common types of rail defects can be found in Annex B. The IM may define more stringent limits based upon performance and overall risk management of the infrastructure.

Some defect types do not directly lead to cracks growing in the rail, but will affect the performance of the track system and need to be removed. For these defect types, end of economic maintenance limits L_{E_end} is typically used. One example is corrugation, where the values presented in EN 13231-5:2018 represent end of economic maintenance limits L_{E_end}.

7 Risk mitigation

Risk management starts with the implementation of the track-testing framework, develops on the detection of a defect and ends with the actual removal of the defect. Upon detecting a rail defect and based on the actual circumstances in the track, a variety of measures should be considered in order to mitigate the risk of failure before the rail can be changed:

— reducing line speed;

— mounting fishplates, if feasible for that type of defect;

— increase the frequency of inspection, up to constant surveillance;

— restriction of the use for special types of railway vehicles;

— closing the track.

Several factors other than defect type and size shall be taken into account when assessing the risks that defects have on the structural integrity of the rail:

— line speed, category and type of traffic;

— multiple isolated defects within a short distance or cluster density of defects over longer length;

— expected crack growth until removal;

— location of the defect site in the track;

— track condition including geometry;

— rail profile and current condition such as wear and corrosion;

— steel grade;

— manufacturing process;

— accumulated tonnage;

— site history;

— low rail temperatures causing tensile stress in the rail of continuously welded track.

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Annex A
(informative)

Description of rail defects

A.1 Definition and description of rail defects

The general coding system for rail defects and the classification of the different types of defect are shown in Table A.1.

The codes in Table A.1 apply to vignole rail only.

Table A.1 — Rail defect coding system

<table>
<tr><th>1st digit</th><th>2nd digit</th><th>3rd digit</th><th>4th digit</th></tr>
<tr><td>Situation</td><td>Location</td><td>Pattern, nature</td><td rowspan="3">Additional characteristics and differentiations</td></tr>
<tr><td rowspan="2">1. Rail ends
2. Plain rails</td><td>0. Full section
1. Rail head
3. Web
5. Foot</td><td>0. Unknown origin
1. Transverse
2. Horizontal
3. Longitudinal vertical
4. Corrosion
5. Passing through a hole
6. Not passing through a hole
9. Lap</td></tr>
<tr><td>2. Surface of rail head</td><td>0. Wear
1. Rolling Surface defects
2. Gauge corner defects
3. Crushing
4. Local batter
5. Wheel burns
7. Cracking and local subsidence of the running surface
8. Dripping water</td></tr>
<tr><td>Situation</td><td>Location</td><td>Origin, cause</td><td>(No 4th digit)</td></tr>
<tr><td>3. Defects caused by damage to rail</td><td>0. Full section</td><td>1. Bruising
2. Faulty machining
3. Permanent deformation</td><td></td></tr>
</table>

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1st digit	2nd digit	3rd digit	4th digit
Situation	**Welding method**	**Pattern, nature**	
4. Welding and resurfacing defects	1. Electric flash-butt welding 2. Aluminothermic welding 3. Electric arc welding 4. Oxyacetylene (autogenous) welding 5. Pressurized gas welding 6. Induction welding 7. Resurfacing 8. Other welding methods	1. Transverse 2. Horizontal or shelling 5. Wheel burns 7. Cracking and local subsidence of the running surface	**Additional characteristics and differentiations**

Numbering of rail defects.

Each rail defect is assigned a number shown in Table A.2.

Table A.2 — Numbering of rail defects

1	**Defects in rail ends**			
	11/12	Head		
		111	Transverse cracking	
		112	Horizontal cracking	
		113	Longitudinal vertical cracking	
		114	Corrosion	
		121	Surface defects	
			1211	Spalling
			1212	Long groove
			1213	Rolling lap
		122	Shelling of running surface	
			1221	Flaking
			1222	Shelling
			1223	Head checking
		123	Crushing	
		124	Local batter of running surface	
		125	Isolated wheel burn	
		127	Squat, cracking and local depression of the running surface	

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	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	Cracking of fishbolt holes	
		139	Lap	
	15	Foot		
		153	Longitudinal vertical cracking	
		154	Corrosion	
2	**Defects in plain rails**			
	20	Full section		
		200	Transverse break without identified origin	
	21/22	Head		
		211	Transverse cracking	
		212	Horizontal cracking	
		213	Longitudinal vertical cracking	
		214	Corrosion	
		220	Wear	
			2201	Short-pitch corrugation
			2202	Short-wave and long-wave corrugation
			2203	Excessive lateral wear
			2204	Excessive vertical wear
		221	Running surface defects	
			2211	Spalling
			2212	Long groove
			2213	Rolling lap
		222	Gauge corner defects	
			2221	Flaking
			2222	Shelling
			2223	Head checking
		223	Crushing	
		224	Local batter of the running surface	

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		225	Wheelburn	
			2251	Isolated wheelburn
			2252	Multiple wheelburns
		227	Squat, cracking and local depression of the running surface	
		228	Local depression of the running surface caused by dripping water in tunnels	
	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	
		239	Lap	
	25	Foot		
		251	Transverse fracture of machined rail	
		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	
4	**Welding and resurfacing defects**			
	41	Electric flash-butt welding		
		411	Transverse cracking of the profile	
		412	Horizontal cracking of the web	
		417	Squat, cracking and local depression of the running surface	
	42	Alumino-thermic welding		
		421	Transverse cracking of the profile	
		422	Horizontal cracking of the web	
		427	Squat, cracking and local depression of the running surface	
	43	Electric arc welding		
		431	Transverse cracking of the profile	

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		432	Horizontal cracking of the web
		437	Squat, cracking and local depression of the running surface
	47	Resurfacing	
		471	Transverse cracking of the rail head
		472	Detachment or shelling of the resurfaced portion
	48	Other welding methods	
		481	Transverse cracking in rail from electrical connection

A.2 Characterization of rail defects

A.2.1 Transverse cracking

A.2.1.1 General

Table A.3 — Transverse cracking

Defect type
Transverse cracking
Code-numbers and names
111 Transverse cracking 211 Transverse cracking 411 Transverse cracking in electric flash-butt welds 421 Transverse cracking in alumino-thermic welds 431 Transverse cracking in electric arc welds

A.2.1.2 Appearance, causes and location - Transverse cracking

Table A.4 — Transverse cracking

Transverse cracking (111 / 211)
Transverse cracking initiates in the central of the rail head or in the gauge corner area. It is a manufacturing defect caused by internal inclusions or hydrogen micro cracks. Impact loads are crack developing factors. When a rail break occurs before the defect becomes visible, a smooth, shiny kidney-shaped patch can be observed. When the crack reaches the surface of the railhead the surface of the crack starts to oxidize. Railbreak is imminent at this stage. Not to be confused with transverse cracking from the rail head surface, e.g. head checks or shelling, or with transverse cracking under resurfacing (471), or with transverse crack on welds (411).

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Figure A.1 — 211 – Central origin



Figure A.2 — 211 – Origin in the gauge corner area

Table A.5 — Transverse cracking in welds

Transverse cracking in welds (411 / 421 / 431)
Transverse cracking in welds initiates in electric flash-butt welds, in aluminothermic welds and electric arc welds. It is a manufacturing defect caused by welding design and process or by internal inclusions. Not to be confused with sudden arcing near the weld, e.g. bruising (301).

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Figure A.3 — 411 – Internal defect of the head in the weld



Figure A.4 — 421 – Internal defect of the foot in the weld

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Figure A.5 — 421 – Crack located largely in the vertical plane



Figure A.6 — 421 – Break from crack in the vertical plane in the weld

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Figure A.7 — 431 – Transverse cracking of the profile in electric arc joint weld

A.2.2 Horizontal cracking

A.2.2.1 General

Table A.6 —Horizontal cracking

Defect type
Horizontal cracking
Code-numbers and names
112 Horizontal cracking in the head at rail end 132 Horizontal cracking in the web at rail end 1321 Horizontal cracking in the web-head fillet radius at rail end 1322 Horizontal cracking in the web-foot fillet radius at rail end 212 Horizontal cracking in the head in plain rail 232 Horizontal cracking in the web in plain rail 2321 Horizontal cracking in the web-head fillet radius in plain rail 2322 Horizontal cracking in the web-foot fillet radius in plain rail 412 Horizontal cracking in the web in electric flash-butt weld 422 Horizontal cracking in the web in alumino-thermic weld 432 Horizontal cracking in the web in electric arc weld

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A.2.2.2 Appearance, causes and location

A.2.2.2.1 Horizontal cracking in the head

Table A.7 — Horizontal cracking in the head

Horizontal cracking in the head (112 / 212)
Horizontal cracking in the head initiates in the railhead and progresses parallel to the running surface. Development is accelerated by impact loads at joints of poor conditions. It may result in local depression of the running surface, which may be characterized by a dark patch contrasting with the shiny surface of the running band. 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 may be accompanied by a vertical crack or progress into a transverse crack. At a later stage, a piece of metal may break away. Not to be confused with longitudinal vertical cracking or with shelling (2222) of running surface.



Figure A.8 — 212 – Horizontal cracking in the head of plain rails

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