BS EN 16273:2014

BSI Standards Publication

Railway applications — Track — Forged rail transitions

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National foreword

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The UK participation in its preparation was entrusted to Technical Committee RAE/2, Railway Applications - Track.

A list of organizations represented on this committee can be obtained on request to its secretary.

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Bahnanwendungen - Oberbau - Geschmiedete Schienenübergänge

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EUROPEAN COMMITTEE FOR STANDARDIZATION
COMITÉ EUROPÉEN DE NORMALISATION
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Foreword

This document (EN 16273:2014) 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of an identical text or by endorsement, at the latest by June 2015 and conflicting national standards shall be withdrawn at the latest by June 2015.

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Introduction

This European Standard has three main topics:

— requirements of a forged part;

— procedure approval;

— forged rail production following approval.

This European Standard satisfies the needs of the railway authority and the manufacturer should achieve the specified requirements of this standard.

1 Scope

This European Standard specifies the requirements for the approval of a process wherein a rail of one profile has part of its length forged to a different profile, together with the requirements for subsequent forging production and product acceptance.

This European Standard applies to new railway rails according to EN 13674-1, and to switch and crossing rails used in conjunction with railway rails 46 kg/m and above according to EN 13674-2, to be welded or fish plated to make up switch rails or transition rails intended for use on railway infrastructures.

2 Normative references

The following documents, in whole or in part, are normatively referenced in this document and are indispensable for its application. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

EN 13232–5:2005+A1:2011, *Railway applications – Track – Switches and crossings – Part 5: Switches*

EN 13674-1:2011, *Railway applications – Track – Rail – Part 1: Vignole railway rails 46 kg/m and above*

EN 13674-2, *Railway applications – Track – Rail – Part 2: Switch and crossing rails used in conjunction with Vignole railway rails 46 kg/m and above*

EN ISO 3452-1, *Non-destructive testing – Penetrant testing – Part 1: General principles (ISO 3452-1)*

EN ISO 9934 (all parts), *Non-destructive testing – Magnetic particle testing (ISO 9934)*

3 Terms and definitions

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

3.1
manufacturer
company that produces forged switch and transition rails

3.2
purchaser
buyer of the forged switch or transition rails

3.3
railway infrastructure
permanent way of national or private railways

3.4
specimen
portion detached from a forged rail transition and prepared as required for testing

3.5
profile finishing
operation by which the rail or relevant part of the component is returned to required profile

Note 1 to entry: This operation can be by grinding, milling, planing or any other suitable means.

3.6
finished condition
finished component

3.7
railway authority (RA)
either the railway regulator or the owner of the railway infrastructure or the custodian with a delegated responsibility for a railway infrastructure

3.8
forged switch rail – flexible switch rail
the switch rail in the movable area of the switch is made of one profile only. This can be either a standard rail profile or a special profile

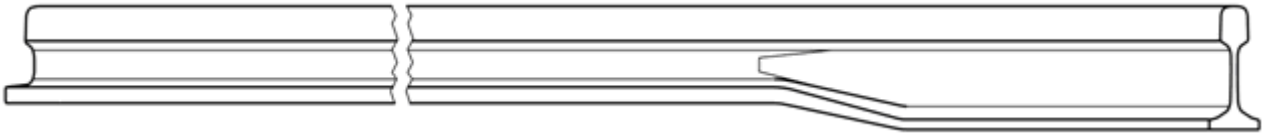
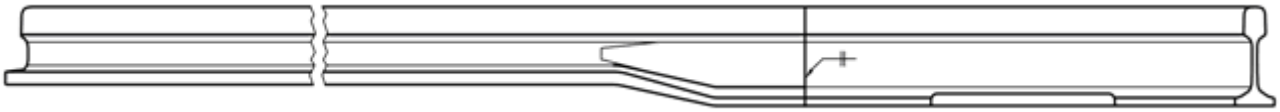


Figure 1 — Forged switch rail – flexible switch rail

3.9
forged switch rail – spring rail switch – rail
the switch rail in the movable area of the switch is made of two different profiles. The transition and the weld between one to the other profile takes place in the movable part of the switch rail and can be either a standard rail profile or a special profile



key

Flash butt weld

Figure 2 — Forged switch rail – spring rail switch – rail

3.10
forged switch rail – forged part
the forged part is the end section of a switch rail with the transition. It is made of one profile only

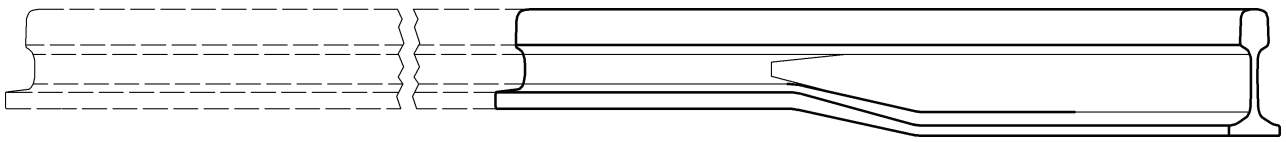


Figure 3 — Forged switch rail – forged part

3.11
forged transition rail
part of a symmetrical vignole rail profile 1 forged to another symmetrical vignole rail profile 2

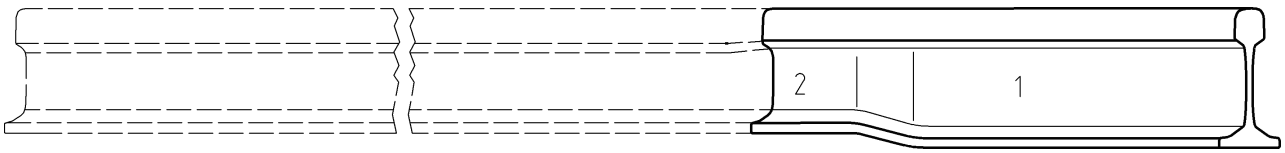


Figure 4 — Forged transition rail

3.12
forged rail transition
a rail of one profile having part of its length forged to a different profile. A rail with an asymmetrical profile forged to a symmetrical profile is a forged switch rail (see 3.8, 3.9 and 3.10). A rail with a symmetrical profile forged to another symmetrical profile is termed a forged transition rail (see 3.11)

3.13
heat affected zone (HAZ)
part of the rail heated to a temperature affecting the hardness

4 Information to be supplied for approval

4.1 By the purchaser

The following information shall be supplied by the purchaser, agreed with the manufacturer and shall be fully documented:

— the initial and final rail profiles, length of the switch rail or transition rail and geometrical requirements of the rail transition;

— the rail grade;

— the profile class of the rail leg-end extension as specified in EN 13674-1 and EN 13674-2.

4.2 By the manufacturer

The following information shall be supplied by the manufacturer, agreed with the purchaser and shall be fully documented:

— a drawing of the switch or transition rail.

5 Approval of the manufacturer

The manufacturer shall operate an independently approved quality assurance system or an other quality assurance system accepted by the purchaser.

6 Requirements for the forging process

6.1 General

All heating, forging, cooling and dressing shall be carried out in a controlled process.

6.2 Forging parameters

The forging process and any post heat treatment, including the working ranges, shall be determined during procedural trials. Once approval has been granted they shall not be changed without prior purchaser approval.

The parameters shall be monitored and checked against approval limits. These records shall be referenced to the relevant products.

6.3 Post heat treatment

Post heating or controlled post cooling may be required and shall in such case be monitored.

6.4 Profile finishing

The finishing shall be carried out in the longitudinal direction using machining and optionally additional grinding. The roughness limit shall be maximum 6,3 Ra.

The profile finishing shall not cause any thermal or mechanical damage. The rail profile in the wheel contact area shall be maintained during profile finishing.

The profile finishing shall not end in the zone S (see Figure 8).

6.5 Cutting to length

The switch rails shall be cut square, in accordance with Table 9 in EN 13674-1:2011, to the requested length. Burrs shall be removed from all edgings. Flame cutting is not allowed for the final cut.

6.6 Identification

The identification shall permit traceability to production records. Every forged rail blank shall be encoded by:

— the sign of the manufacturer;

— the year of manufacturing;

— the identification number for the forged part.

The identification shall permit the traceability of the product for at least the guarantee period.

7 Procedure approval

7.1 General

Procedure approval tests shall be done for the production of switch and transition rails by the manufacturer as described in chapter 7 of this standard. For grade R260 rails, approval is granted by grade (not per profile). For grade R350HT rails, approval is granted by grade (not per profile) and by rail manufacturer.

Procedure approval shall be carried out by testing samples produced in accordance with this standard; the samples shall be representative of those carried out in production. One failure during the approval tests described in 7.4 and 7.5 involves the rejection of the approval.

Refer to 7.7 for re-qualification requirements.

7.2 Test specimen preparation

The test specimens shall be produced and inspected by the same method used for production pieces.

7.3 Number of specimens

Four test specimens in the finished condition (see 3.6) shall be manufactured.

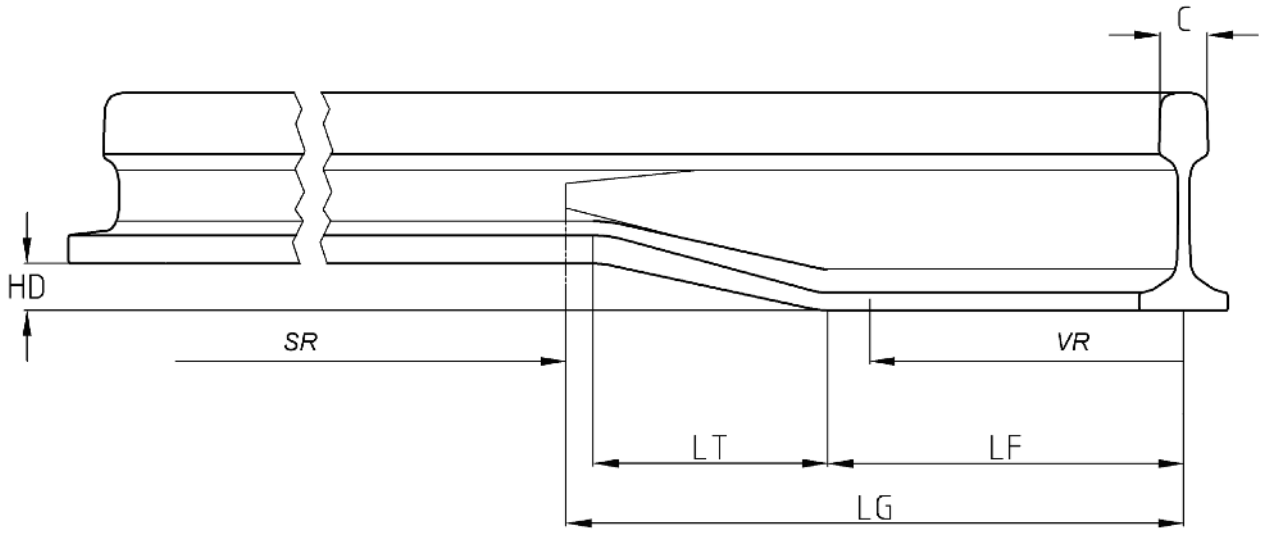
7.4 Non-destructive approval tests

7.4.1 Geometry and dimensions

7.4.1.1 Switch rails

The dimension of the forged rail head and the profile of the vignole rail at the heel of the switch rail shall comply with the tolerances in Table 1.

Figure 5 indicates the parts of the forged rail that shall be checked according to Table 1.



Key

SR switch rail

VR vignole rail

NOTE For further terms shown in this Figure, see Table 1.

Figure 5 — Dimensions of forged switch rail

Table 1 — Length and tolerances for the forged switch rail

Dimension	**Length [mm]**	**Measurement equipment**
Length of the forged rail transition **LT**	Minimum 3 x HD	Measuring stick, tape or gauge
Dimension	**Admissible tolerance [mm]**	**Measurement equipment**
Length that ends where the switch rail profile begins **LG**	±20	Measuring stick, tape or gauge
Length of the vignole part measured on the foot **LF**	±20	Measuring stick, tape or gauge
Vertical alignment across the running surface along the longitudinal centre line starting at the forged rail end until 1500 mm, measured by moving a 1 m straight edge and a thickness gauge.	- 0,1 / + 0,2	1 m straight edge and a thickness gauge
Horizontal alignment on the running edge at 14 mm below the running surface, starting at the forged rail end until 1500 mm measured by moving a 1 m straight edge and a thickness gauge.	±0,4	1 m straight edge and a thickness gauge
Head profile concavity (EN 13232–5:2005+A1:2011, Figure 18) **HC**	An area of concavity may exist only on the opposite of the running edge. This shall not exceed 2 mm	1 m straight edge and a thickness gauge
Vertical twist (twist base length 1 m)	±0,5	Method agreed between the manufacturer and the purchaser
Head profile **C**	+0,6 / −0,3	Gauge E.4 according to EN 13674–1:2011 dependent on the rail profile
Height difference from one rail foot to the other rail foot (Figure 5) **HD**	±1,1	Method agreed between the manufacturer and the purchaser
Other measuring methods can be used but in case of dispute, the equipment described above shall be used.		

Other tolerances for the vignole profile shall be in accordance with EN 13674-1:2011, Table 7, profile class X.

Figure 6 shows the definitions of the algebraic sign in the alignment measurement.

Dimensions in millimetres

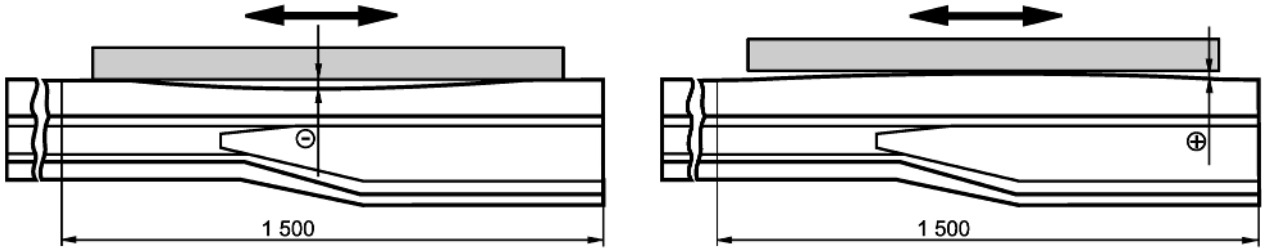
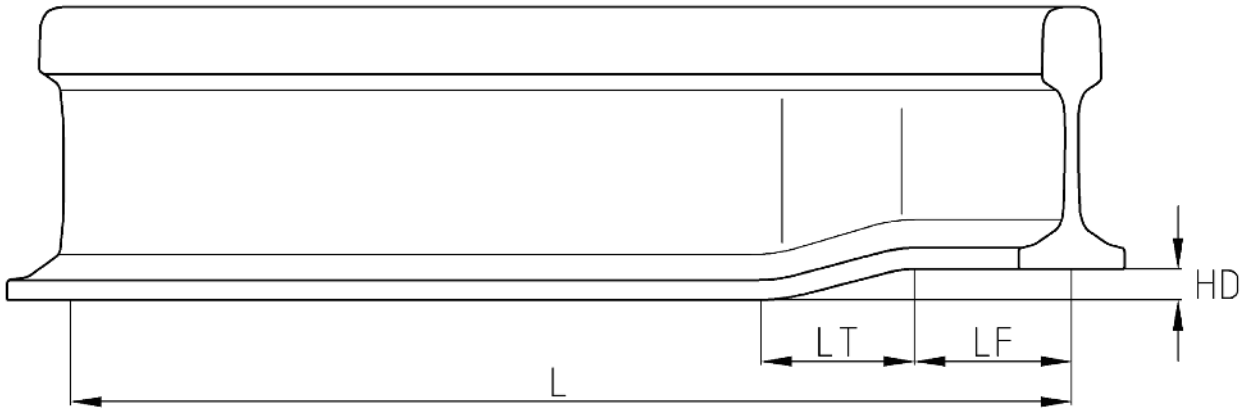


Figure 6 — Definitions of the algebraic sign

7.4.1.2 Transition rails

The dimension of the transition rail shall comply with the tolerances in Table 2.

Figure 7 indicates the parts of the transition rail that shall be checked according to Table 2.



NOTE For terms shown in this Figure, see Table 2.

Figure 7 — Dimensions of forged rail transition

Table 2 — Tolerances for the transition rail, before welding

Dimension	**Length [mm]**	**measurement equipment**
Length of the forged rail transition **LT**	Minimum 3 x HD	measuring stick, tape or gauge
Dimension	**Admissible tolerance [mm]**	**measurement equipment**
Length of the forged vignole part, measured on the foot **LF**	±20	measuring stick, tape or gauge
Total length of the transition rail **L**	±20	measuring stick, tape or gauge
Vertical alignment across the running surface	- 0,1 / + 0,2	1 m straight edge and a

along the longitudinal centre line measured by moving a 1 m straight edge and a thickness gauge.		thickness gauge
Horizontal alignment on the running edge at 14 mm below the running surface measured by moving a 1 m straight edge and a thickness gauge.	±0,4	1 m straight edge and a thickness gauge
Other measuring methods can be used but in case of dispute, the equipment described above shall be used.		

7.4.2 Visual inspection

For all the specimens in the finished condition, the forged part shall be inspected for cavities, cracks, damage and geometrical non-conformities. No cracks are accepted.

The depth of hot marks and seams shall not exceed:

— 0,35 mm for the running surface, the gauge corner and the underside of the foot;

— 0,5 mm for the rest of the profile.

In the case of longitudinal marks, there shall be a maximum of two, to the depth limits specified, at any point along the length of the rail but no more than one of these shall be on the rail running surface.

The maximum width of the marks shall be 4 mm. The width to depth ratio of allowable marks shall be a minimum 3:1.

7.4.3 Surface finish

The roughness of all the specimens shall be checked against 6.4 and shall conform with the requirements in 6.4.

7.4.4 Dye penetrant (DPI) or magnetic particle inspection (MPI)

On completion of visual inspection the forged part shall be tested by non-destructive testing method:

— dye penetrant inspection according to EN ISO 3452-1;

or

— magnetic particle inspection according to series EN ISO 9934.

No linear indications are accepted; no round indications with size bigger than 3mm are accepted.

7.4.5 Ultrasonic testing (UT)

For switch rails all specimens shall be tested by an ultrasonic method at the forged part, agreed with the customer. In case of dispute the method described in Annex A shall be used.

The acceptance criteria are the following:

— registration limit: ≥ 50 % reference line

— indications ≥ reference are not acceptable

For transition rails, the UT is not required.

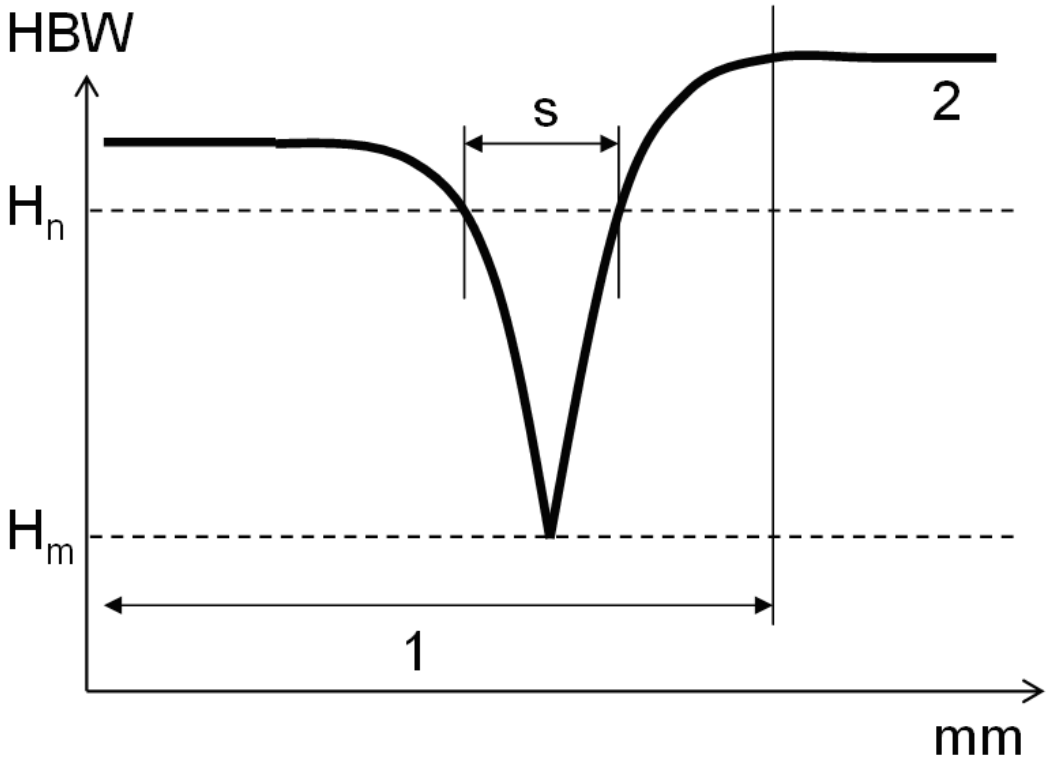
7.5 Destructive approval tests

7.5.1 Hardness distribution

A Brinell hardness HBW 5/750 or HBW 2,5/187,5 distribution shall be performed on the four specimens with a stationary machine. To prepare the hardness tests on the running surface the rail head shall be milled off 0,5 mm up to maximum 1 mm.

The testing of hardness shall be performed along the longitudinal centre line following Figure 9 for switch rails and Figure 10 for transition rails until the hardness of the parent rail is reached.

The indicated hardness values of the switch rail shall be in the range of the specifications in Table 3 and Figure 8. The indicated hardness values of the transition rail shall be in the range of the specifications in Table 3.



Key

H_n nominal hardness of the parent rail grade

H_m minimum hardness in zone S according to Table 3

s width between the two nominal hardness points on the hardness distribution curve

1 HAZ

2 parent rail

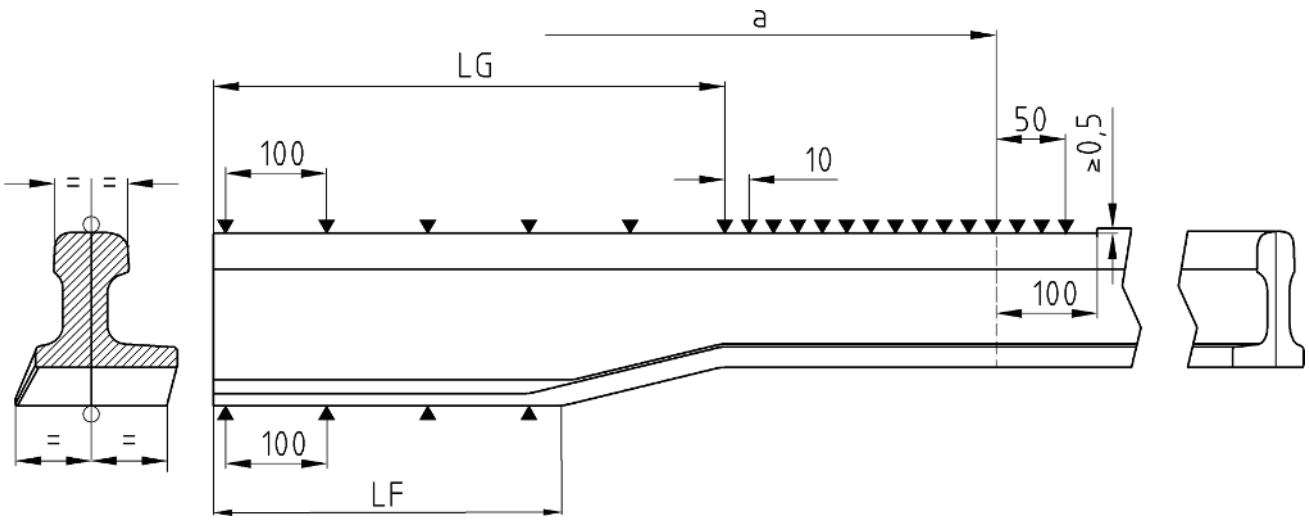
Figure 8 — Hardness distribution of a switch rail

An isolated hardness value falling outside of the minima and maxima stated in Table 3 shall be accepted when such a hardness value falls between the two adjacent values that conform to the requirements.

Table 3 — Reference values for hardness on the rail

grade of the switch	reference values [HBW 5/750 / HBW 2,5/187,5] for the rail		
	head		foot
	HAZ, except zone S	Zone S	forged part
R260	260 to 300 (310) (max. 5 hardness points may fall over 300 to max. 310)	min. 220 (max. 5 hardness points may fall below Hn = 260)	max. 300
R350HT	350 to 390	min. 280 (max. 5 hardness points may fall below Hn = 350)	max. 390
grade of the transition rail	reference values [HBW 5/750 / HBW 2,5/187,5] for the rail		
	head		foot
R260	measured hardness of parent rail - 40/+ 40		

Dimensions in millimetres



Key

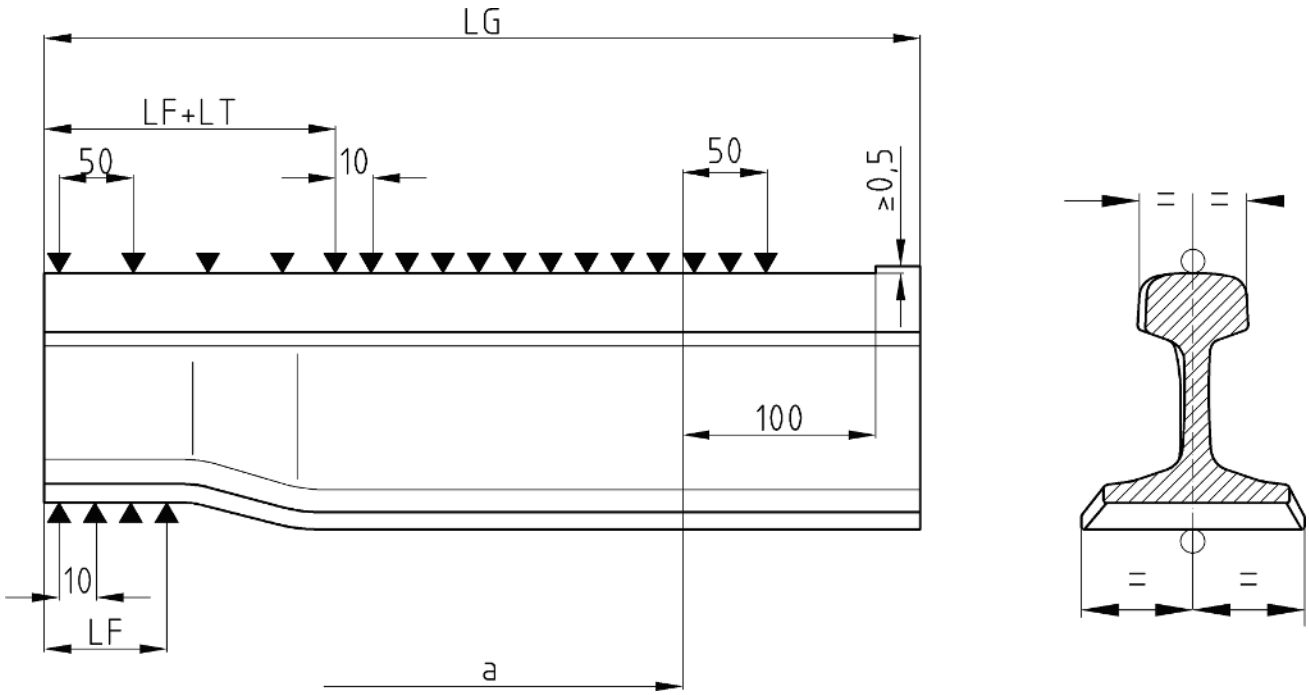
▼ place of inspection on the running surface

▲ place of inspection on the foot

a end of forged heat affected zone

Figure 9 — Examination of hardness spreading in the heat affected zone for switch rail

Dimensions in millimetres



Key

▼ place of inspection on the running surface

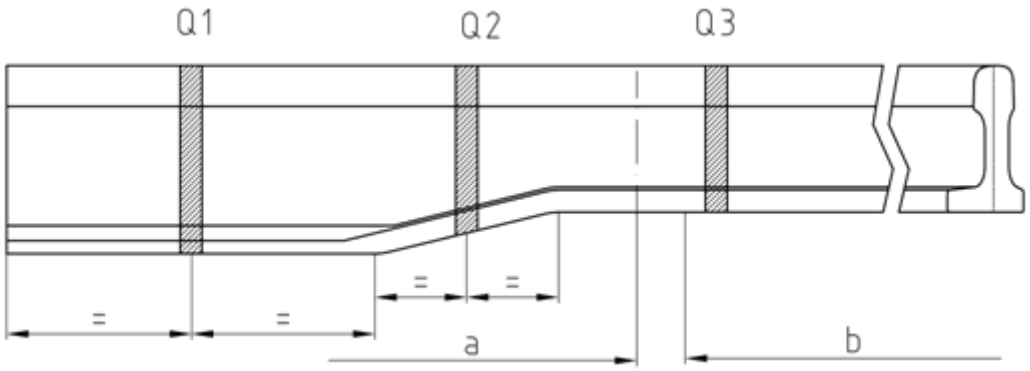
▲ place of inspection on the foot

a end of forged heat affected zone

Figure 10 — Examination of hardness spreading in the heat affected zone for transition rail

7.5.2 Switch rails: hardness distribution in the rail head

For switches, from one specimen, three samples for hardness distribution in the head shall be prepared according to Figure 11. The hardness distribution Vickers HV30 in the rail head should be investigated according to EN ISO 6507-1. The positions and the places of inspection for the hardness indents are shown in Figure 12. The series of tests start with the first hardness indent at a distance of 1 mm below the surface. The hardness indents shall have a distance of 2 mm between them.

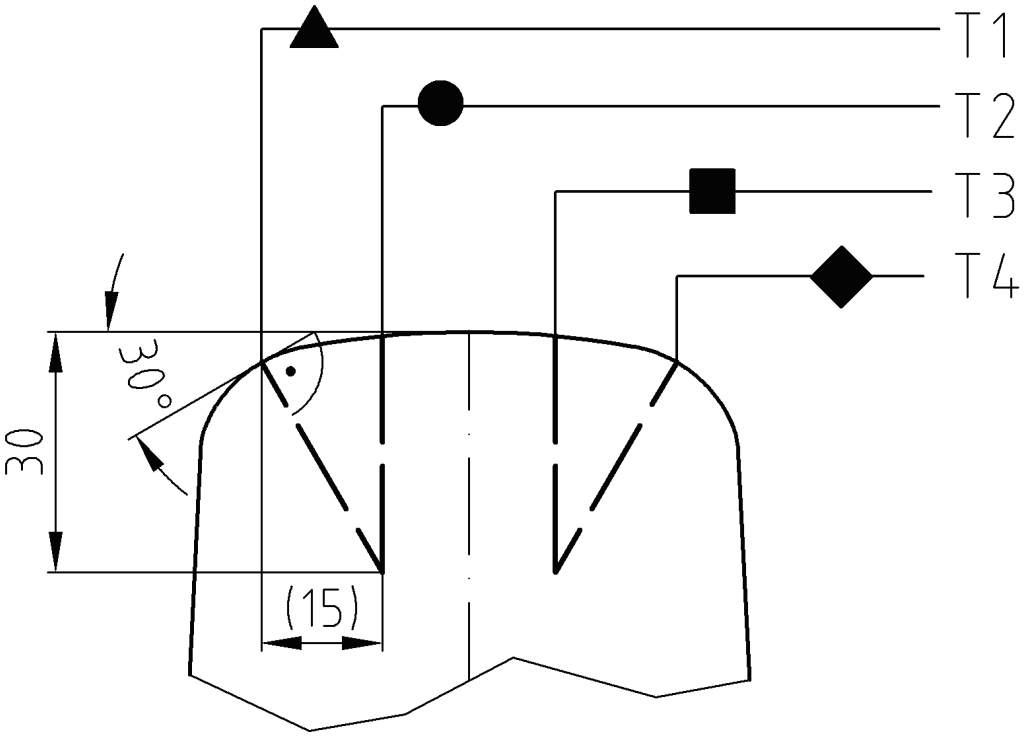


Key

a	end of forged heat affected zone
b	unaffected parent rail
Q1 – Q3	transverse specimens

Figure 11 — Position of the samples for hardness distribution on the switch rail

Dimensions in millimetres



Key

T1 – T4	location of the hardness distribution

Figure 12 — Testing of hardness distribution in the rail head

The hardness values (Vickers HV 30) of the rail head distribution shall be in the range as specified in Table 4. The decrease of hardness between two adjacent indents shall not be more than 20HV.

Table 4 — Switch rail: reference values for hardness in the rail head

Forged rail	Hardness [HV 30]	
	hardness indent at a distance of 1 mm to the surface	hardness indent at a distance of 15 mm to the surface
grade R260	265 to 305	≥ 260
grade R350HT	360 to 400	≥ 300
An isolated hardness value falling outside of the stated minima and maxima above shall be permitted when such a hardness value falls between the two adjacent values that conform to the requirements.		

7.6 Test report

A report which contains the results shall be produced.

The test report shall include as a minimum:

— identification of the machine;

— identification of the document describing the forging process including post treatment and the working ranges;

— rail grade;

— the rail manufacturer for heat treated rails;

— results of all approval tests. Annex B may be used for the documentation of the results of all approval tests of forged switch rails and transition rails.

7.7 Validity of approval

Re-approval of procedures is required at least once every five years and when:

— steel grades or steel production methods are changed;

— changes are made to production parameters within an approved process. Adaptations within the working ranges of the process are allowed.

8 Production tests

8.1 Switches

8.1.1 General

The manufacturer shall ensure the quality of the forged rail transition by testing according to Table 5.

Table 5 — Production tests for switches

Test	Frequency	Results
Visual inspection	Each piece	7.4.2
Surface finish	Each piece	7.4.3
Geometry	Each piece	8.1.2
NDT (MPI or DPI)	Each piece	7.4.4
NDT (UT)	Each piece	7.4.5
Hardness	For each grade and profile: the first and last produced piece of 1 day	8.1.3
NOTE NDT: Non destructive testing		

8.1.2 Geometry and dimensions

The dimension of the forged rail head and the profile of the vignole rail at the heel of the switch rail shall comply with the tolerances in 7.4.1.1. Additionally the dimensions in Table 6 shall be checked during production.

Table 6 — Additional tolerances for the forged switch rail

Dimension	Admissible tolerance	Measurement equipment
total length of the switch rail **LA**	length ≤ 24 m: ±3 mm 24 m < length ≤ 35 m: ±4 mm length > 35 m: ±20 mm	tape measure

NOTE Tolerances are valid for dimension measurements in temperature range 20°C ± 5°C. LA according to EN 13232–5:2005+A1:2011, Figure 14.

8.1.3 Hardness testing

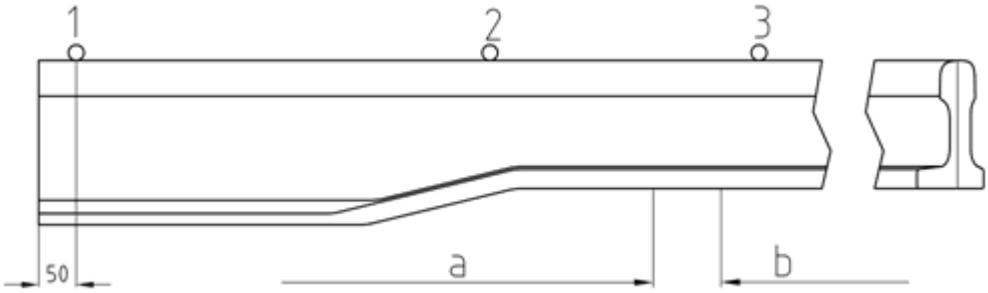
The switch rail shall be investigated by a Brinell hardness testing device or a device allowing conversion to HBW. To prepare the hardness tests, 0,5 mm shall be removed locally on the head outside the running surface. The hardness of the rail head shall be measured 3 times at each position (Figure 13):

— place of inspection 1 in the zone of extended vignole profile (50 mm);

— place of inspection 2 in the transition zone;

— place of inspection 3 in the parent rail, outside the heat affected zone.

Dimension in millimetres



Key

1, 2 and 3 are measurement points

a end of forged heat affected zone

b unaffected parent rail

Figure 13 — Hardness testing of the rail head

The average hardness value at each position shall be in the range of specification of Table 3. Deviations from the reference values depending on the use of mobile testing devices shall be agreed with the purchaser. Values outside the specification of Table 3 shall result in rejection of the piece N, additionally all the pieces produced before the rejected piece shall be checked beginning with the piece N-1 and continuing until three consecutive pieces in accordance with Table 3 have been found. To reach the hardness values, one additional heat treatment is allowed.

8.2 Transition rails

8.2.1 General

The manufacturer shall ensure the quality of transition rails by testing according to Table 7.

Table 7 — Production tests on transition rails

Test	Frequency	Results
Visual inspection	Each piece	7.4.2
Surface finish	Each piece	7.4.3
Geometry	Each piece	7.4.1.2
Hardness	For each grade and profile: the first and last produced piece of 1 day	8.2.2

8.2.2 Hardness test

The transition rail shall be investigated by a Brinell hardness testing device or a device allowing conversion to HBW.

To prepare the hardness tests on the head, 0,5 mm shall be removed locally, outside the running surface. The hardness of the rail head shall be measured three times at each position (Figure 14):

— place of inspection 1 in the forged profile (50 mm);

— place of inspection 2 in the transition zone;

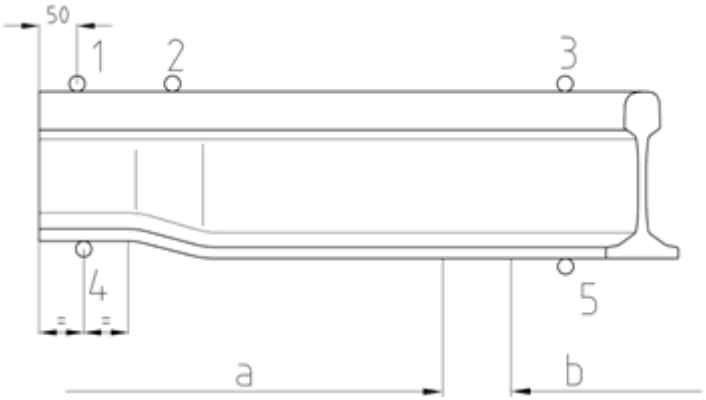
— place of inspection 3 in the parent rail, outside the heat affected zone.

To prepare the hardness tests on the foot, the measurement position shall be ground. The hardness of the rail foot shall be measured three times at each position (Figure 14):

— place of inspection 4 in the middle of the forged zone;

— place of inspection 5 in the parent rail.

Dimension in millimetres



Key

1 – 5 are measurement points

a end of forged heat affected zone

b unaffected parent rail

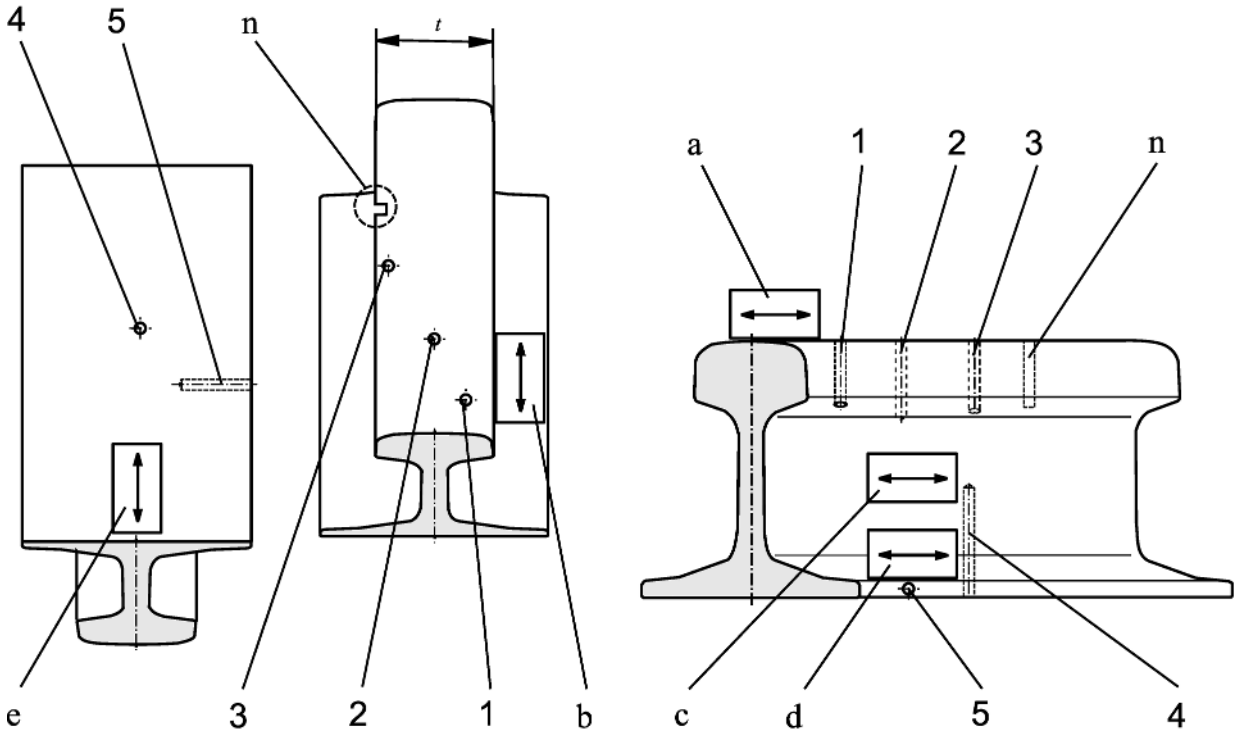
Figure 14 — Hardness testing of the transition rail (head + foot)

The average hardness value at each position on the head and the foot shall be in the range of specification of Table 3. Deviations from the reference values depending on the use of mobile testing devices shall be agreed with the purchaser. Values outside the specifications shall result in rejection of the piece N, additionally all the pieces produced before the rejected piece shall be checked beginning with the piece N-1 and continuing until three consecutive pieces in accordance with the specifications have been found. To reach the hardness values, one additional heat treatment is allowed.

Annex A
(informative)

Ultrasonic testing

A.1 Reference line (DAC) generation – reference block



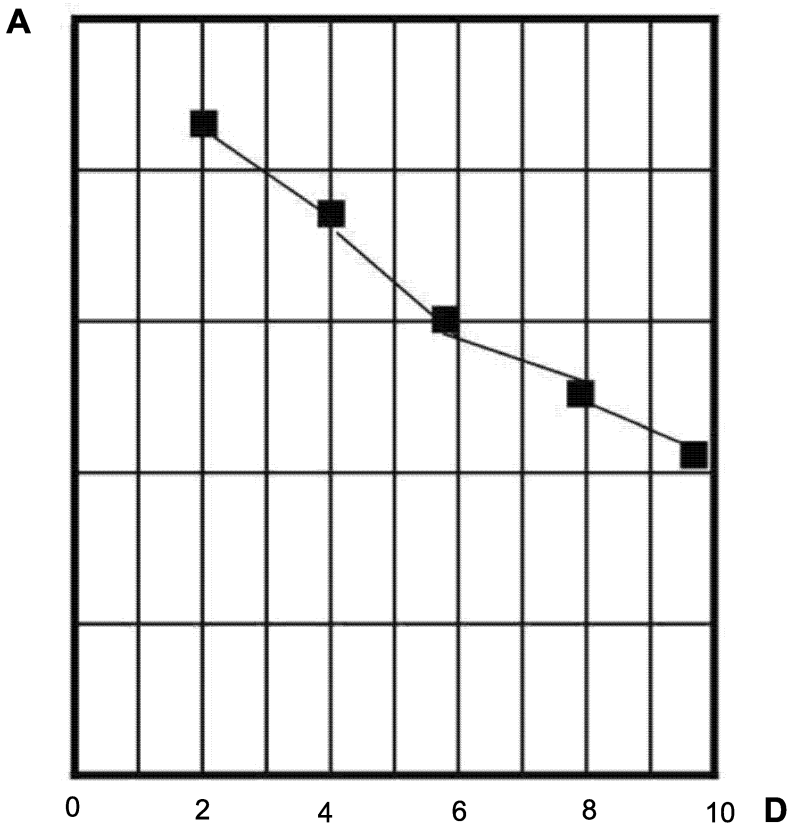
Key

1, 2, 3	1/4, 1/2, 3/4 head-width thickness, 3 mm drilling, depth: min. 35 mm DAC generation
4	2 mm drilling, depth: min. 60 mm, check
5	2 mm drilling, depth: min. 35 mm, check
n	notch, width: 3 mm depth: 1,5 mm length: head height
b	probe position reference line generation
a, b, c, d, e	probe positions production tests in both directions (b, c, d on both sides of rail)
t	head width

Probes shall be appropriate to detect the holes.

Figure A.1 — Reference line (DAC) generation – Reference block

A.2 Reference line (DAC) generation and acceptance criteria



Key

A amplitude corresponding to the echo height of drillings and notches, measured in % screen height

D distance

■ points connected = reference line

Figure A.2 — Reference line (DAC) generation and acceptance criteria at position b

The following criteria to be taken into account are the following:

— The largest echo from holes 1, 2, 3 and n shall be set to 80 % of full screen height (FSH).

— Distance scale:

  — 1/4 thickness echo to 2 scale parts;

  — 1/2 thickness echo to 4 scale parts;

  — 3/4 thickness echo to 6 scale parts;

  — notch echo to 8 scale parts;

  — 3/4 thickness echo, indirect, to 10 scale parts.

Annex B
(informative)

Documentation of approval tests

This template can be used for the documentation of the results of all approval tests of forged switch rails and transition rails.

B.1 Forged switch rails

B.1.1 General

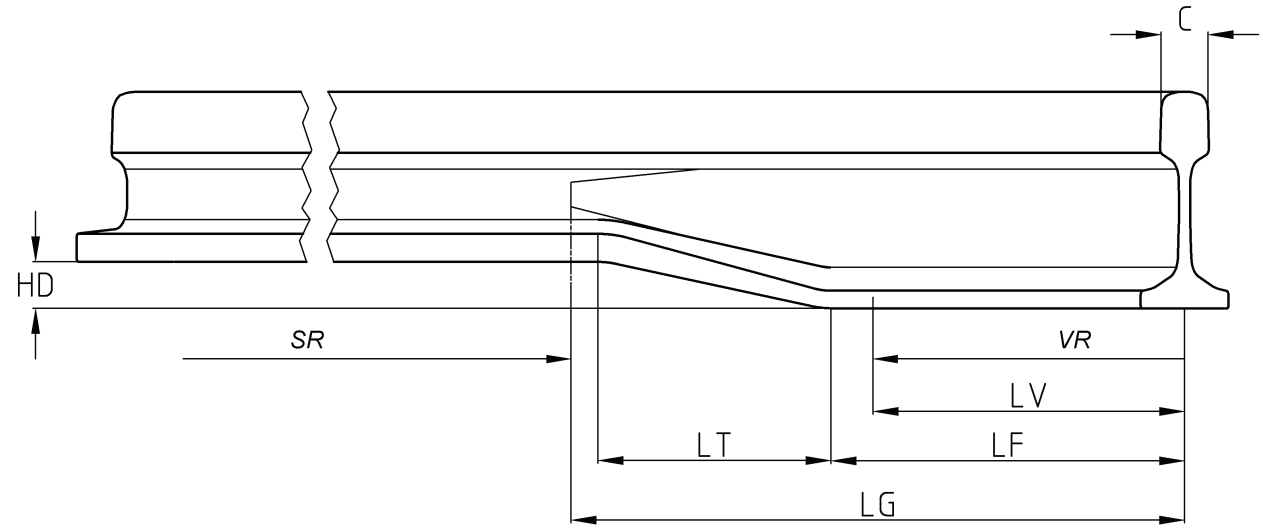
Table B.1 — General information

1	Component	- flexible switch - spring rail switch - forging part for switches			
2	Rail profile				
3	Steel grade	- R260 - R350HT			
4	Sign of the manufacturer				
5	Year of manufacturing				
6	Identification number for the forged rail transition (4 test specimens)				
7	Inspector / laboratory				
8	Date of report				

Table B.2 — Geometry and dimensions

Dimension	Designed value	Specimen 1	Specimen 2	Specimen 3	Specimen 4
Length of the forged rail transition **LT ≥ 3 x HD**					
Length of the forged vignole part, when delivered without weld, measured on the foot **LF ± 20 mm**					
LG ± 20 mm					
Length of the vignole part measured in the web **LV ± 20 mm**					
Vertical alignment across the running surface along the longitudinal centre line starting at the forged rail end until 1500 mm, measured by moving a 1 m straight edge and a thickness gauge.	0 mm				

Dimension	Designed value	Specimen 1	Specimen 2	Specimen 3	Specimen 4
(−0,1 / +0,2) mm					
Horizontal alignment on the running edge at 14 mm below the running surface, starting at the forged rail end until 1500 mm, measured by moving a 1 m straight edge and a thickness gauge. **± 0,4 mm**	0 mm				
Head profile concavity (EN 13232–5:2005+A1:2011, Figure 18) **HC**	0 mm				
Vertical twist (twist base length 1 m) **± 0,5 mm**	0 mm				
Crown profile (gauge E.4) **C (+0,6 / −0,3) mm**					
Height difference from one rail foot to the other rail foot (Figure 5) **HD ± 1,1 mm**					
Height of the rail (gauge E.3) **H** (see EN 13674–1)					
Width of the rail head (gauge E.5) **WH ± 0,5 mm**					
Height of fishing (gauge E.8) **HF** (see EN 13674–1)					
Width of rail foot (gauge E.10) **WF ± 1 mm**					
Rail asymmetry (gauge E.6 and E.7) **AS ± 1,2 mm**	0 mm				
Web thickness (gauge E.9) **WT (+1,0 / −0,5) mm**					
Depth of hot marks and seams on the running surface and the underside of the foot of the forged part: **0,35 mm**	0 mm				
Depth of hot marks and seams on the rest of the profile of the forged part: **0,5 mm**	0 mm				
Cracks on the finished specimens	No cracks are allowed				
Roughness of the machined surface **6,3 Ra**					



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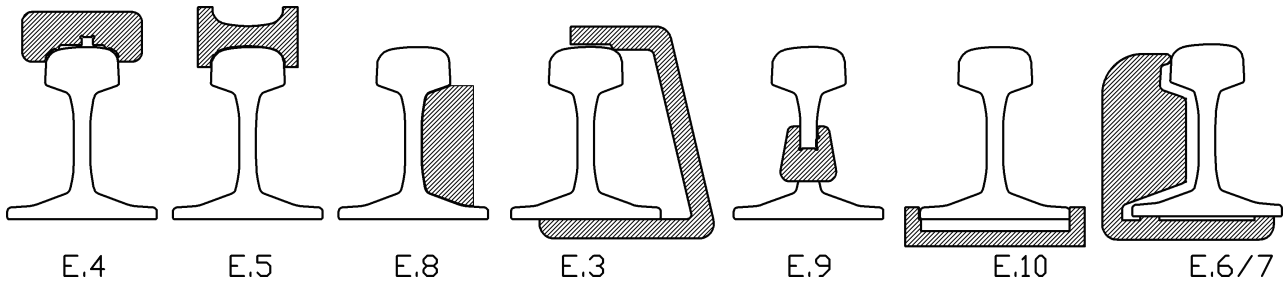


b)

NOTE For keys shown in the figures in Annex B, see Table B.2.

Figure B.1 — Geometry and dimension testing of the forged vignole rail

Table B.3 — Dye penetrant (DPI) or magnetic particle inspection (MPI)

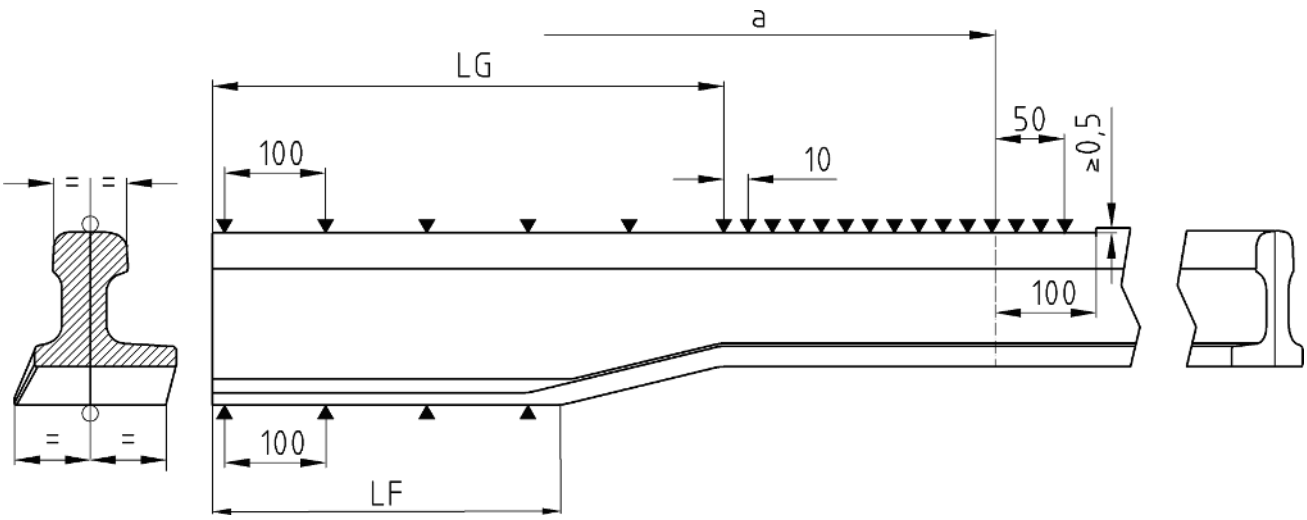
	Specimen 1	Specimen 2	Specimen 3	Specimen 4
Used non-destructive testing method				
Inspector / laboratory				
Date of report				
Test result				
Remarks				
Signature				

Table B.4 — Ultrasonic testing (UT)

	Specimen 1	Specimen 2	Specimen 3	Specimen 4
Used device for the ultrasonic testing (UT)				
Inspector / laboratory				
Date of report				
Test result				
Remarks				
Signature				

B.1.2 Hardness distribution on the surface

Dimensions in millimetres



Key

Distance end of the forged vignole rail / end of heat affected zone a = mm

Figure B.2 — Examination of hardness distribution in the heat affected zone for switch rail

Table B.5 — Test results of hardness distribution on the rail head

	Specimen	Place of inspection inside LG [mm]									
		10	110	210	310	410	510	610	710	810	910
Hardness [HBW]	1										
	2										
	3										
	4										
	Specimen	Place of inspection outside LG [mm]									
		10	20	30	40	50	60	70	80	90	100
Hardness [HBW]	1										
	2										
	3										
	4										
	Specimen	Place of inspection outside LG [mm]									
		110	120	130	140	150	160	170	180	190	200
Hardness [HBW]	1										
	2										
	3										
	4										

	Specimen	Place of inspection outside LG [mm]									
		210	220	230	240	250	260	270	280	290	300
Hardness [HBW]	1										
	2										
	3										
	4										
	Specimen	Place of inspection outside LG [mm]									
		310	320	330	340	350	360	370	380	390	400
Hardness [HBW]	1										
	2										
	3										
	4										

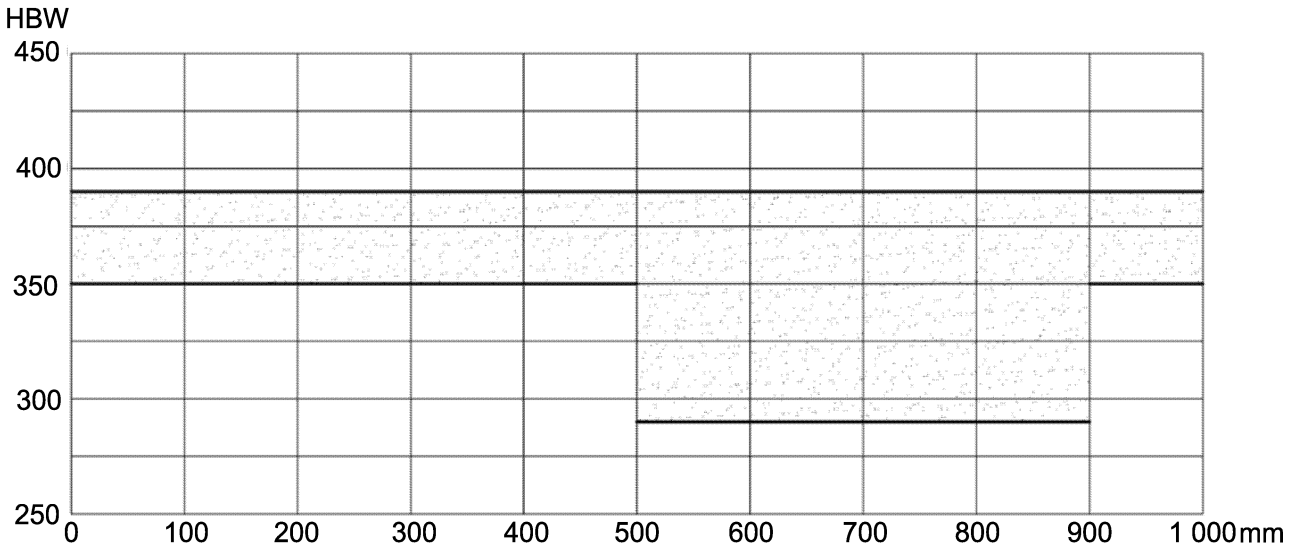


Figure B.3 — Hardness distribution in the heat affected zone for switch rail grade R350 HT
(max. 5 hardness points may fall below 350HBW)

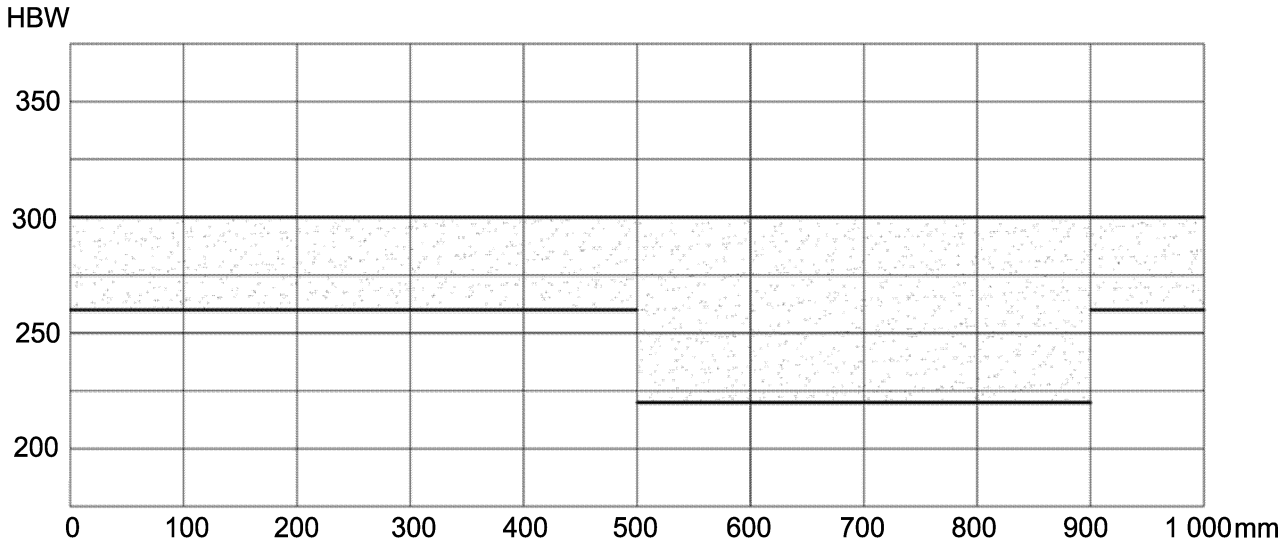
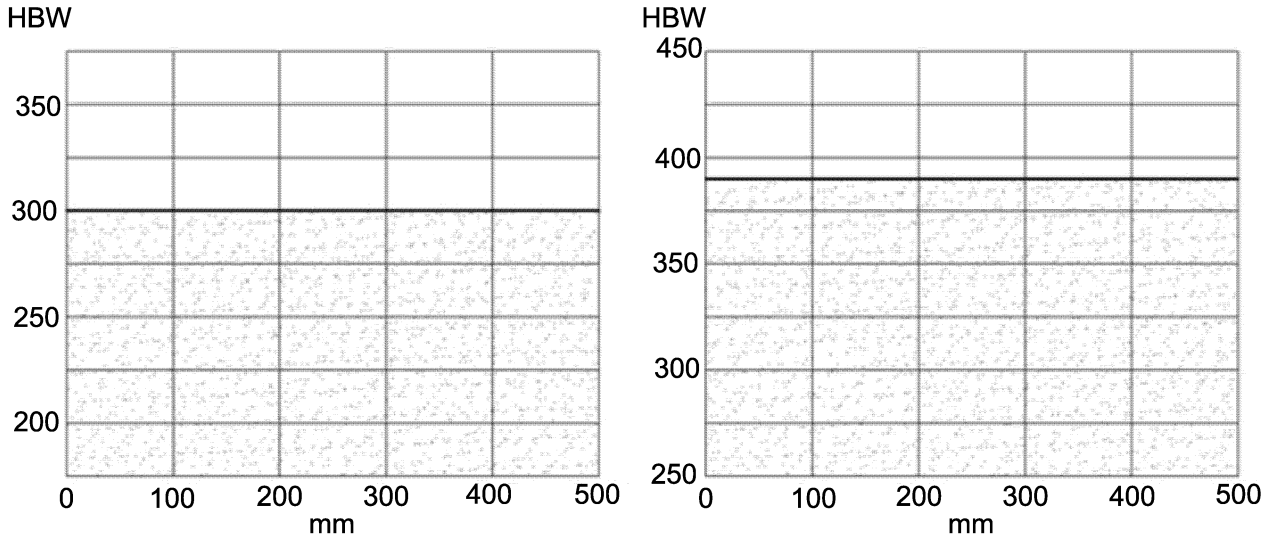


Figure B.4 — Hardness distribution in the heat affected zone for switch rail grade R260
(max. 5 hardness points may fall below 260HBW)

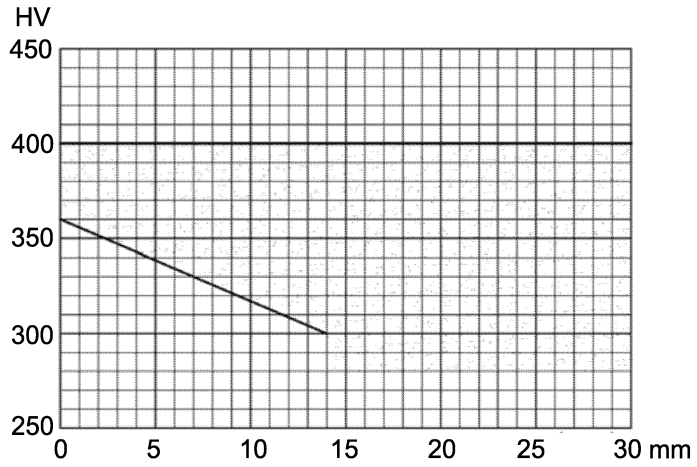
Table B.6 — Test results of hardness distribution on the rail foot

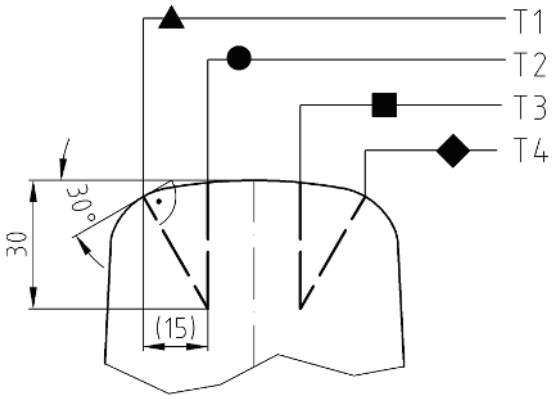
	Specimen	Place of inspection [mm]									
		10	110	210	310	410	510	610	710	810	910
Hardness [HBW]	1										
	2										
	3										
	4										



Rail grade R260 Rail grade R350HT

Figure B.5 — Hardness distribution on the foot of a switch rail grade R260 or R350 HT

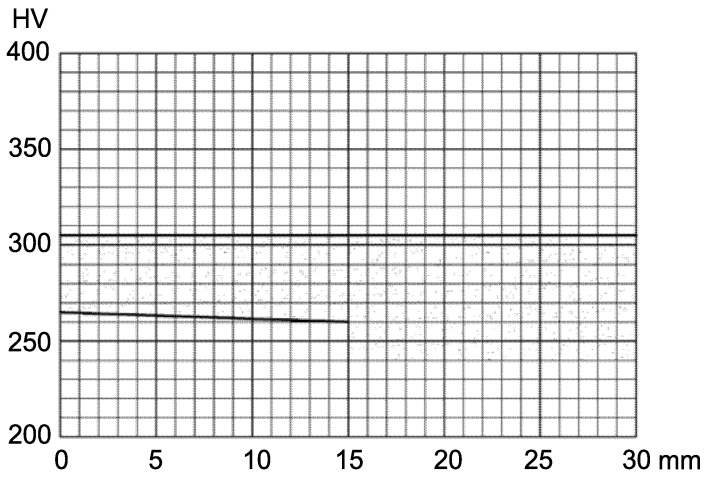


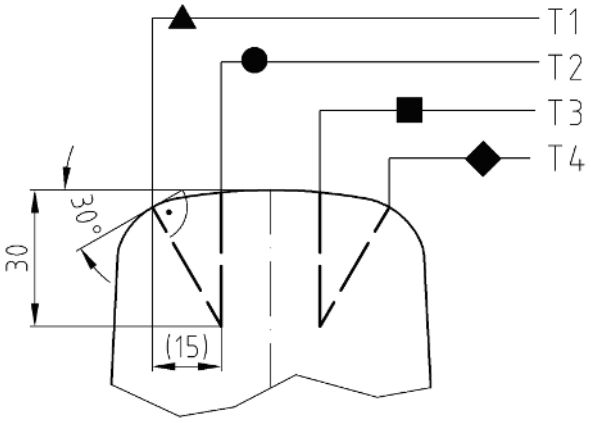


T1 – T4: location of the hardness distribution

Specimen	**……**
Grade	**R350HT**
HV	**5 / 10 / 30**

Figure B.6 — Hardness distribution in the rail head / grade R350HT





T1 – T4: location of the hardness distribution

Specimen	**……**
Grade	**R260**
Q	**……..**
HV	**5 / 10 / 30**

Figure B.7 — Hardness distribution in the rail head / grade R260

B.2 Forged transition rails

B.2.1 General

Table B.7 — General information

1	Rail profile				
2	Steel grade	R260			
3	Sign of the manufacturer				
4	Year of manufacturing				
5	Identification number for the forged rail transition (4 test specimens)				
6	Inspector / laboratory				
7	Date of report				

Table B.8 — Geometry and dimensions

Dimension	Designed value	Specimen 1	Specimen 2	Specimen 3	Specimen 4
Length of the forged rail transition **LT > 3 x HD**					
Length of the forged vignole part, measured on the foot **LF ± 20 mm**					
Total length of the forged rail transition **LG ± 20 mm**					
Vertical alignment across the running surface along the longitudinal centre line measured by moving a 1 m straight edge and a thickness gauge. (**-0,1 / +0,2) mm**	0 mm				
Horizontal alignment on the running edge at 14 mm below the running surface measured by moving a 1 m straight edge and a thickness gauge. **± 0,4 mm**	0 mm				
Depth of hot marks and seams on the running surface and the underside of the foot of the forged part: **0,35 mm**	0 mm				
Depth of hot marks and seams on the rest of the profile of the forged part: **0,5 mm**	0 mm				
Cracks on the finished specimens	No cracks are allowed				
Roughness of the machined surface **6,3 Ra**					

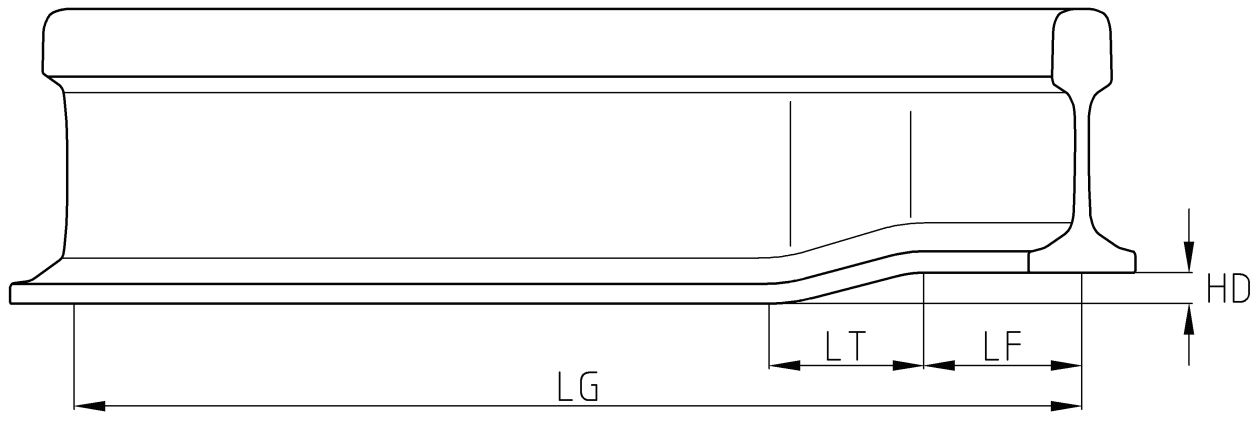


Figure B.8 — Geometry and dimension testing of the forged vignole rail

Table B.9 — Dye penetrant (DPI) or magnetic particle inspection (MPI)

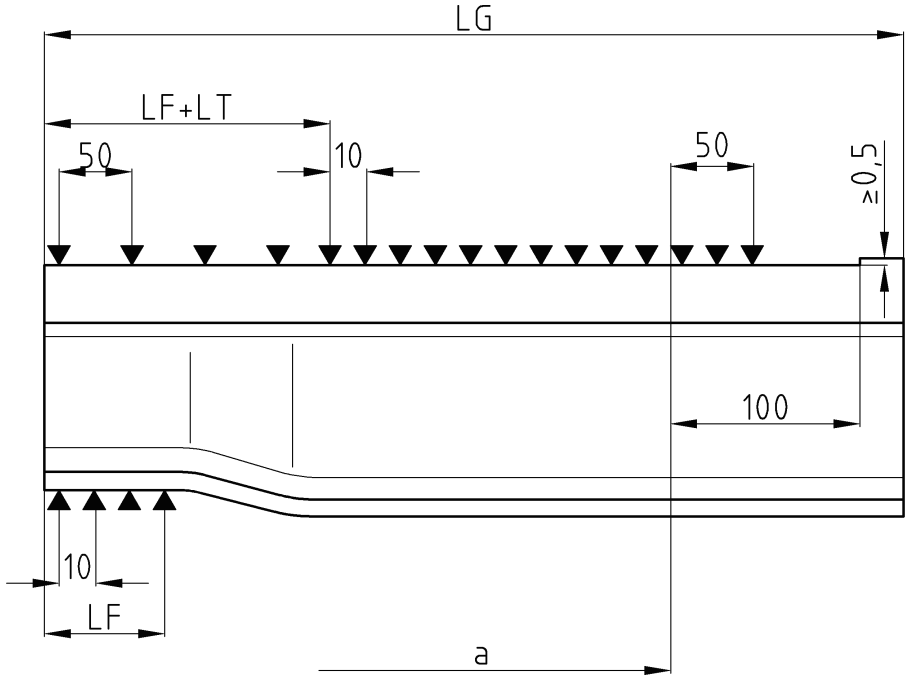
	Specimen 1	Specimen 2	Specimen 3	Specimen 4
Used non-destructive testing method				
Inspector / laboratory				
Date of report				
Test result				
Remarks				
Signature				

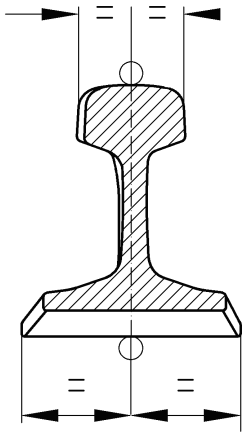
Table B.10 — Ultrasonic testing (UT)

	Specimen 1	Specimen 2	Specimen 3	Specimen 4
Used device for the ultrasonic testing (UT)				
Inspector / laboratory				
Date of report				
Test result				
Remarks				
Signature				

B.2.2 Hardness distribution on the surface

Dimensions in millimetres





Key

Distance end of the forged vignole rail / end of heat affected zone a = mm

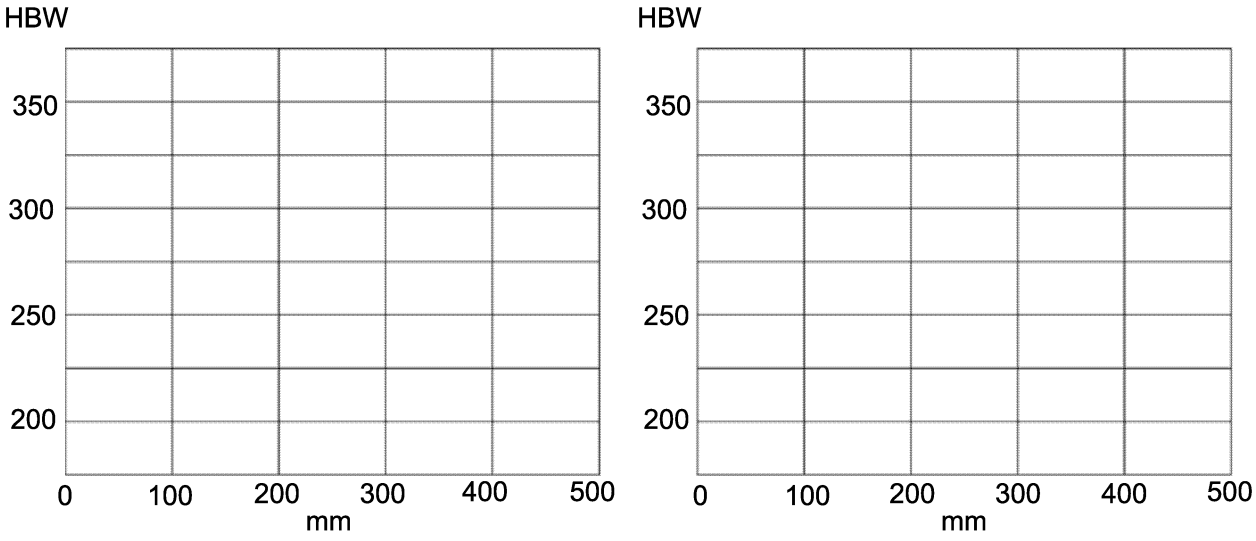
Figure B.9 — Examination of hardness distribution in the heat affected zone for transition rail

Table B.11 — Test results of hardness distribution on the rail head

	Specimen	Place of inspection inside LG [mm]									
		10	60	110	160	210	260	310	360	410	460
Hardness [HBW]	1										
	2										
	3										
	4										
	Specimen	Place of inspection outside LG [mm]									
		10	20	30	40	50	60	70	80	90	100
Hardness [HBW]	1										
	2										
	3										
	4										
	Specimen	Place of inspection outside LG [mm]									
		110	120	130	140	150	160	170	180	190	200
Hardness [HBW]	1										
	2										
	3										
	4										
	Specimen	Place of inspection outside LG [mm]									
		210	220	230	240	250	260	270	280	290	300
Hardness [HBW]	1										
	2										
	3										
	4										

Table B.12 — Test results of hardness distribution on the rail foot

	Specimen	Place of inspection [mm]									
		10	20	30	40	50	60	70	80	90	100
Hardness [HBW]	1										
	2										
	3										
	4										



Place of inspection “Head” Place of inspection “Foot”

Measured values [HBW 5/750 or HBW 2,5/187,5] shall be in a range of (−40 to +40) HBW of measured hardness of parent rail.

Figure B.10 — Hardness distribution on the head and on the foot in the heat affected zone for transition rail

Bibliography

[1] EN ISO 6506-1, *Metallic materials - Brinell hardness test - Part 1: Test method (ISO 6506-1)*

[2] EN ISO 6507-1, *Metallic materials - Vickers hardness test - Part 1: Test method (ISO 6507-1)*

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