BRITISH STANDARD

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+A1:2009

Railway applications — Track — Rail —

Part 4: Vignole railway rails from 27 kg/m to, but excluding 46 kg/m

ICS 45.080

BSI
British Standards

National foreword

This British Standard is the UK implementation of EN 13674-4:2006+A1:2009. It supersedes BS EN 13674-4:2006 which is withdrawn.

The start and finish of text introduced or altered by amendment is indicated in the text by tags. Tags indicating changes to CEN text carry the number of the CEN amendment. For example, text altered by CEN amendment A1 is indicated by [A1] 〈A1〉.

The UK participation in its preparation was entrusted to Technical Committee RAE/2, Railway track components.

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

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Railway applications - Track - Rail - Part 4: Vignole railway rails from 27 kg/m to, but excluding 46 kg/m

Applications ferroviaires - Voie - Rail - Partie 4: Rails Vignole de masse comprise entre 27 kg/m et 46 kg/m, 46 kg/m non compris

Bahnanwendungen - Oberbau - Schienen - Teil 4: Vignolschienen mit einer längenbezogenen Masse zwischen 27 kg/m und unter 46 kg/m

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Foreword

This document (EN 13674-4:2006+A1:2009) 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of an identical text or by endorsement, at the latest by May 2010, and conflicting national standards shall be withdrawn at the latest by May 2010.

Attention is drawn to the possibility that some of the elements of this document may be the subject of patent rights. CEN [and/or CENELEC] shall not be held responsible for identifying any or all such patent rights.

This document includes Amendment 1, approved by CEN on 2009-09-22.

This document supersedes EN 13674-4:2006.

The start and finish of text introduced or altered by amendment is indicated in the text by tags ⟨A1⟩ ⟨A1⟩.

This part of EN 13674 is the fourth of the series EN 13674 *Railway applications – Track – Rail* which consists of the following parts:

— Part 1: Vignole railway rails 46 kg/m and above;

— Part 2: Switch and crossing rails used in conjunction with Vignole railway rails 46 kg/m and above;

— Part 3: Check rails;

— Part 4: Vignole railway rails from 27 kg/m to, but excluding 46 kg/m.

Other standards planned for publication include the following:

— ⟨A1⟩ EN 14587-1 Railway applications– Track – Flash butt welding of rails – Part 1: New R220, R260, R260Mn and R350HT grade rails in a fixed plant;

— EN 14587-2 Railway applications – Track – Flash butt welding of rails – Part 2: New R220, R260, R260Mn and R350HT grade rails by mobile welding machines at sites other than at a fixed plant;

— prEN 14587-3 Railway applications – Track – Flash butt welding of rails – Part 3: Welding in association with crossing construction;

— EN 14730-1 Railway applications – Track – Aluminothermic welding of rails – Part 1: Approval of welding processes;

— EN 14730-2 Railway applications – Track – Aluminothermic welding of rails – Part 2: Qualification of aluminothermic welders, approval of contractors and acceptance of welds;

— EN 14811 Railway applications – Track – Special purpose rail – Grooved and associated construction;

— EN 15594 ⟨A1⟩ Railway applications – Track – Restoration of rails by electric arc welding.

According to the CEN/CENELEC Internal Regulations, the national standards organizations of the following countries are bound to implement this European Standard: Austria, Belgium, Bulgaria, Cyprus, Czech

Republic, Denmark, Estonia, Finland, France, Germany, Greece, Hungary, Iceland, Ireland, Italy, Latvia, Lithuania, Luxembourg, Malta, Netherlands, Norway, Poland, Portugal, Romania, Slovakia, Slovenia, Spain, Sweden, Switzerland and United Kingdom.

Introduction

This introduction provides an explanation of the concepts and reasoning used in the drafting of this European Standard. Its inclusion also ensures that during future revisions, restrictions are removed where technology progresses and held where it does not, thus ensuring continued safety as new manufacturers, products and technologies are introduced.

The most commonly used standards of the world for the supply of railway rails have been reviewed during the preparation of this European Standard. However, modern rail production technology within the European Union has demanded a completely new look at the philosophy and content of this part of EN 13674.

Whenever possible this part of EN 13674 is performance based, recognises the European Quality System standard EN ISO 9001 and requires manufacturers to offer the latest proven technology to consistently satisfy the demanding quality of the required product.

Rail grading is based on hardness rather than tensile strength.

The acceptance tests have been designed to control those characteristics of the rail steel and rail that are of relevance to the production of high quality rails and the demands of the railway.

The steel grades covered by this part of EN 13674 reflect trends in railway usage and heat treated rails are included. This European Standard includes rail profiles for Vignole rails having a linear mass from 27 kg/m to, but excluding 46 kg/m.

To ensure the supply of high quality rails, some restrictions on production processes have been imposed.

This European Standard supersedes national standards covered by the scope. In addition CEN required, where possible, a performance based standard, taking into account safety implications and at the same time addressing modern production technology. It was recognised that there would be few opportunities (and these would have to be for transparent safety considerations) for derogation from this European Standard to operate between the user and the manufacturer.

This European Standard reflects this change in philosophy from the traditional content of rail standards. A review was undertaken of the most commonly used rail standards of the world. All relevant aspects important to both user and manufacturer were considered with the aim of ensuring that all of the content had specific usefulness and relevance. For example rail grading and much of this European Standard has been based on hardness rather than tensile strength. Whilst the two are directly related, hardness is very quick and cheap to carry out and provides more relevant guidance to the user particularly where properties vary in different parts of the profile.

Since many rail manufacturers would not have previously carried out proving trials, this European Standard includes a prerequisite for all manufacturers to prove conformity against a set of qualifying test criteria at the time of tendering. The qualifying tests include all “normal” acceptance test results plus new ‘type-casting’ features such as fracture toughness, fatigue and residual stress (see EN 13674-1). To provide users with the necessary confidence, acceptance limits have been based on results from rail known to have performed well in demanding track installations.

One aspect of this European Standard, which is a complete break from tradition, is the inclusion of quality assurance and inspection clause as part of product integrity.

In order that quality management systems are consistent across all manufacturers and that users have the best assurance for the consistency of required product quality on this safety critical component of the track, the rail standard requires that the manufacturers quality assurance systems are at least equivalent to the requirements of EN ISO 9001. The inclusion of this requirement also reduces the need to incorporate detailed method and calibration descriptions on items such as normal chemical composition determination and the need to define more extensive testing.

Ideally, manufacturing techniques should not be referenced in a product standard. However, some rail attributes are either not known in an exact manner or are not measurable with satisfactory statistical significance. In such cases best practice manufacturing techniques have been included as a last resort. The equipment specified is that which gives the best probability of achieving the required product for use in track. In the future new technology can add to, but preferably will reduce or delete such items.

Examples of areas where the technological state of the art renders the standard less than complete include:

— oxide/oxygen relationships;

— hydrogen test techniques;

— roller straightening effects on residual stresses;

— roller straightening effects on contact scrub;

— measurement and effect of residual stresses throughout the rail.

1 Scope

This part of EN 13674 specifies flat bottom Vignole railway rails from 27 kg/m to, but excluding 46 kg/m.

Five pearlitic steel grades are specified covering a rail hardness range of 200 HBW to 390 HBW and include non-heat-treated non-alloy steels, non-heat-treated alloy steels and heat-treated non-alloy steels.

There are 13 rail profiles specified in this European Standard, but these may not be available in all steel grades.

2 Normative references

The following referenced documents are indispensable for the application of this European Standard. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

〚A1〛 *deleted text* 〚A1〛

EN 10163-1, *Delivery requirements for surface condition of hot-rolled steel plates, wide flats and sections — Part 1: General requirements*

EN 13674-1:2003, *Railway applications — Track — Rail — Part 1: Vignole railway rails 46 kg/m and above*

EN ISO 6506-1, *Metallic materials — Brinell hardness test — Part 1: Test method (ISO 6506-1:2005)*

〚A1〛 EN ISO 6892-1*, Metallic materials – Tensile testing – Part 1: Method of test at room temperature (ISO 6892-1:2009)* 〚A1〛

3 Terms and definitions

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

3.1
heat
one liquid steel melt tapped out of a converter or electric arc furnace which includes after continuous casting a given number of blooms relating to the weight of the heat and the extension of the mixing zone

NOTE In the case of sequence casting the blooms belonging to the mixing zone should be clearly defined.

3.2
sequence
number of heats, of the same steel grade, which undergo continuous casting in tundishes. Tundishes may be used in parallel if the caster has many strands

3.3
heat treated rail
rail that has undergone accelerated cooling from austenitizing temperature during the metallurgical transformation period

3.4
re-heated rail
all rolled rail that has undergone re-austenitization for heat treatment purposes

3.5
mill heat treated rail
heat treated rail that has not undergone re-austenitization after rolling

3.6
rolling process
process between the blooms leaving the heating furnace and exiting the finishing pass

3.7
isothermal treatment process
process whereby blooms are held for a period of time at an elevated temperature for diminishing the hydrogen content

NOTE 1 For maximum efficiency this is as near to (but below) the pearlite to austenite transformation temperature as is practically possible.

NOTE 2 This process is sometimes referred to as sub critical diffusion annealing.

3.8
qualifying tests
special tests and criteria which are relevant to some aspects of the service performance of rails. Acceptance tests also form part of the qualifying tests

3.9
acceptance tests
tests carried out as part of the process and product control system, normally on a heat, sequence or tonnage basis

4 Information to be supplied by the purchaser

The purchaser shall provide the supplier with the following information when inviting tenders to supply:

a) rail profiles (see Annex A);

b) steel grades (see Table 1);

c) lengths of rail including any rails for special purposes (see Table 8);

d) un-drilled or drilled rail ends to take fish plate bolts and the location and dimensions of holes when required (see 9.2.3);

e) any special treatments to be applied to bolt holes;

f) tolerances for bolt holes to which special processes are to be applied (see 9.2.3);

A1 g) cold stamping on the cut surface, if applicable (see 7.4.3); A1

h) paint code requirements (see 7.4.4);

i) tolerances for the horizontal and vertical straightness of un-drilled rail ends (to be welded).

5 Steel grades

The applicable steel grades are given in Table 1. The hardness ranges of the steel grades shall conform to those given in Table 1.

The steel grade designations referred to in this European Standard, are compared to the corresponding steel designations in EN 10027-1 and EN 10027-2 as shown in Annex B.

Table 1 — Steel grades

Grade [a]	Hardness range (HBW)	Description	Branding lines
R200	200 to 240	Non-alloy (C-Mn)	No branding lines
R220	220 to 260	Non-alloy (C-Mn)	_____
R260	260 to 300	Non-alloy (C-Mn)	__ _____
R320Cr	320 to 360	Alloy (1 % Cr)	_____ _____ _____
R350HT	350 to 390 [b]	Non-alloy (C-Mn), heat treated	____ _____ _____

[a] See Table 3 for chemical composition/mechanical properties.

[b] See Table 5 for hardness requirements.

6 Dimensions, static properties, linear mass and tolerances

Rail profiles, dimensions, static properties and linear masses are given in Annex A. The tolerances of certain dimensions shall be as given in Table 6. All other quantities are informative only.

NOTE Linear masses have been calculated based on the density of steel of 7,85 g/cm^3.

7 Manufacture

7.1 Product integrity

7.1.1 Factory production control

Rails shall be produced under a comprehensive system of factory production control, which shall ensure confidence in the conformity of the finished product. The system shall address this European Standard to ensure that the finished products consistently comply with requirements to achieve the product integrity necessary to provide assurance of product safety in track.

Manufacturers shall demonstrate continuing compliance, including documented evidence, with the factory production control system required.

Manufacturers having a factory production control system, which complies with EN ISO 9001 are recognised as satisfying the minimum requirements specified by this clause.

7.1.2 Best practice manufacture

The product shall be manufactured to the best practices as defined in 7.1.1.

NOTE This is to ensure that the rail attributes, described in the Introduction, which are not known in an exact manner or are not practically measurable, achieve the required high level of product integrity in track.

7.2 Blooms

Blooms made from basic oxygen steel or electric arc furnace steel that has been secondary ladle arc refined, vacuum degassed and continuously cast, shall be used for the manufacture of rails.

7.3 Rails

7.3.1 The manufacturer shall operate a procedure for the effective removal of scale during the rolling and straightening processes.

7.3.2 The cross-sectional area of the rail shall not exceed one ninth that of the bloom from which the rail is rolled.

NOTE Other mandatory processes are described in the relevant clauses within the European Standard.

7.4 Identification

7.4.1 Branding

Brand marks shall be rolled in relief on one side and in the middle of the web (see Annex A) of each rail at least once every 4 m. The brand marks on the rails shall be clearly legible and shall be 15 mm to 25 mm high, raised between 0,6 mm and 1,3 mm.

The branding line(s) to denote grade shall be 50 mm in length for the long branding line and 25 mm in length for the short branding line.

The brand marks shall include:

a) identification of the mill;

b) steel grade as shown in Table 1;

c) last two figures of the year of manufacture;

d) rail profile identification as shown in Annex A.

EXAMPLE

ROLLING MILL ___ 98 40E1

(40E1 profile rail rolled 1998, non-alloy rail steel grade R260)

7.4.2 Hot stamping

In addition to the branding requirements of 7.4.1 each rail shall be identified by a numerical and/or alphabetical code system, hot stamped on the non-branded side of the rail web by machine and each rail shall be hot stamped at least once every 5 m.

NOTE Subsequent cutting could result in more than one rail length having the same identity.

The figures and letters used shall be clearly legible and shall be 16 mm high. The stamped characters shall have a flat or radius face (1 mm to 1,5 mm wide) with bevels on each side. The letters and numbers shall be on a 10° angle from vertical and shall have rounded corners. The stamping shall be between 0,5 mm and 1,5 mm in depth along the centre of the web. The design shall be as shown in Figure 1.

The identification system employed shall be such as to enable the hot stamped marking to be collated with:

a) number of the heat from which the rail has been rolled;

b) number of the strand and position of bloom within the strand.

In the event of identification marks having been removed, omitted or requiring alteration, re-identification of such marks shall be made by rotary burr.

7.4.3 Cold stamping

Cold stamping shall only be used on the cut face of the rail within the central portion of the head, at the request of the purchaser.

7.4.4 Other identification

The steel grade may additionally be identified using paint. The purchaser shall specify the colour and position of the paint application.

8 Qualification of the manufacturer

The manufacturer has to qualify under Clause 8 of EN 13674-1:2003 and shall then be qualified for all profiles in this part of EN 13674, provided the qualification was for the profile 60E1, grade R260.

NOTE The qualifying criteria specified in EN 13674-1 may not be achieved using the rail grades specified in this part of EN 13674.

9 Acceptance tests

9.1 Laboratory tests

9.1.1 General

Laboratory tests shall be performed, during production, at frequencies as stipulated in Table 2. Results for each laboratory test shall comply with the limiting values shown in Tables 3 a) and 3 b). Additional information and other acceptance tests not covered by Tables 3 a) and 3 b) shall comply with the requirements of 9.1.2 to 9.1.6 inclusive. All rails supplied shall meet the requirements of Clause 9.

9.1.2 Chemical composition

9.1.2.1 General

The liquid chemical composition shall be determined for each heat. When the solid chemical composition is checked, this shall be carried out at the position of the tensile test piece. The chemical composition shall conform to the requirements of Tables 3 a) and 3 b).

9.1.2.2 Hydrogen

The hydrogen content of the liquid steel shall be measured by determining pressure of hydrogen in the steel using an on-line immersion probe system.

At least two liquid samples shall be taken from the first heat of any sequence using a new tundish and one from each of the remaining heats and analysed for hydrogen content (see Table 2). The first sample from the first heat in a sequence shall be taken from the tundish at the time of the maximum hydrogen concentration.

The heats shall be assessed according to hydrogen content in accordance with Table 4.

The blooms from group 1 heats shall be deemed to be satisfactory.

The blooms from group 2 heats shall be slowly cooled or isothermally treated and all heats shall be tested in the rail form.

Table 2 — Testing frequency

Test (on)	Relevant subclause	Steel grades	
		R200, R220, R260, R320Cr	R350HT
Chemical composition	9.1.2	One per heat	One per heat
Hydrogen	9.1.2.2	One per heat (2 tests from first heat in sequence)	One per heat (2 from first heat in sequence)
Microstructure	9.1.3	Not required for grades R200, R220 and R260 One per 1 000 t or part thereof for grade R320Cr	One per 50 tonnes of re-heated [a c] One per 100 tonnes of mill heat treated [a c]
Decarburisation	9.1.4	One per 1 000 t or part thereof [a b]	One per 500 tonnes of re-heated and mill heat treated [a c]
Hardness	9.1.5	One per heat [a b]	One per 50 tonnes of re-heated [a c] One per 100 tonnes of mill heat treated [a c]
Tensile	9.1.6	One calculation per heat/one test per 2 000 t [a b]	One per heat [a c]

[a] Samples shall be taken at random but only rails from blooms outside the mixing zone between heats when continuously cast in sequence.

[b] Samples shall be cut after rolling.

[c] Samples shall be cut from heat-treated rails.

Table 3 a)— Chemical composition/mechanical properties

Steel grade		% By mass									10^{-4} % (ppm) Max. H [a]	R_m Min.	elong A Min.	Centre line running surface [b]
Steel name	Sample	C	Si	Mn	P max	S max	Cr	Al max.	V max.	N max.		MPa	%	hardness HBW
R200	Liquid	0,40/0,60	0,15/0,58	0,70/1,20	0,035	0,035	0,15 max.	0,004	0,030	0,009	3,0			
	Solid	0,38/0,62	0,13/0,60	0,65/1,25	0,040	0,040	0,15 max.	0,004	0,030	0,010	3,0	680	14	200/240
R220	Liquid	0,50/0,60	0,20/0,60	1,00/1,25	0,025	0,025	0,15 max.	0,004	0.030	0,008	3,0			
	Solid	0,50/0,60	0,20/0,60	1,00/1,25	0,025	0,025	0,15 max.	0,004	0,030	0,008	3,0	770	12	220/260
R260	Liquid	0,62/0,80	0,15/0,58	0,70/1,20	0,025	0,025	0,15 max.	0,004	0.030	0,009	2,5			
	Solid	0,60/0,82	0,13/0,60	0,65/1,25	0,030	0,030	0,15 max.	0,004	0.030	0,010	2,5	880	10	260/300
R320Cr	Liquid	0,60/0,80	0,50/1,10	0,80/1,20	0,020	0,025	0,80/1,20	0,004	0,18	0,009	2,5			
	Solid	0,58/0,82	0,48/1,12	0,75/1,25	0,025	0,030	0,75/1,25	0,004	0,20	0,010	2,5	1 080	9	320/360
R350HT	Liquid	0,72/0,80	0,15/0,58	0,70/1,20	0,020	0,025	0,15 max.	0,004	0,030	0,009	2,5			
	Solid	0,70/0,82	0,13/0,60	0,65/1,25	0,025	0,030	0,15 max.	0,004	0,030	0,010	2,5	1 175	9	350/390

[a] See 9.1.2.2.

[b] See Figure 8.

Table 3 b) — Maximum residual elements, % by mass

	Mo	Ni	Cu	Sn	Sb	Ti	Nb	Cu & 10 Sn	Sum of elements	
R200, R220, R260	0,02	0,10	0,15	0,030	0,020	0,025	0,01	0,35	Cr + Mo + Ni + Cu + V :	0,35
R320Cr	0,02	0,10	0,15	0,030	0,020	0,025	0,01	0,35	Ni + Cu :	0,16
R350HT	0,02	0,10	0,15	0,030	0,020	0,025	0.04	0,35	Cr + Mo + Ni + Cu + V :	0,25

Table 4 — Hydrogen content of heats

Heats	Hydrogen content 10^{-4} % (ppm)	
	Steel grades R200 and R220	All other steel grades
Group 1	≤ 3,0	≤ 2,5
Group 2	> 3,0	> 2,5

If the hydrogen contents of the first samples of a first heat or the heat sample of a second or further heat do not comply with the requirements of Table 3 a) then the blooms made before those samples are taken shall be slowly cooled or isothermally treated. Also all blooms made before the hydrogen content eventually complies with the requirements in Table 3 a) shall be slowly cooled or isothermally treated.

When testing of rails is required rail samples shall be taken at the hot saw at a frequency of one per heat at random. However on the first heat in a sequence, the rail sample shall be from the last part of a first bloom teemed on any strand. Hydrogen determination shall be carried out on samples taken from the centre of the rail-head.

If any test result after the corrective treatment of group 2 rails fails to meet the requirements stated in Table 3 a) the heat shall be rejected.

9.1.3 Microstructure

9.1.3.1 General

Microstructures shall be determined at a magnification of x 500.

The microstructure shall be verified for R320Cr and heat-treated rails at the frequency given in Table 2.

The testing position in the rail-head shall be as shown in Figure 2.

9.1.3.2 Grade R320Cr

The microstructure shall be fully pearlitic with no martensite, bainite or grain boundary cementite.

9.1.3.3 Grade R350HT

The microstructure shall be pearlitic with no martensite, bainite or grain boundary cementite. The maximum grain boundary ferrite permitted is shown in Figure 3.

9.1.4 Decarburisation

The decarburisation shall be checked at the frequency shown in Table 2. The decarburisation depth shall be assessed by means of a hardness test. After a minimum of preparation of the rail surface (polishing) a hardness test according to the method indicated in 9.1.7 will be performed in three points. None of the results of hardness obtained shall be lower than the minimum value specified of the grade, reduced by 7HBW. (example: 253HBW for grade R260).

If there are any doubts regarding the conformity with the requirements on decarburisation, alternatively to the hardness test, at the discretion of the manufacturer or on request of the purchaser, metallographic investigations shall be carried out.

Photomicrographs showing the depth of decarburisation allowed are shown in Figure 4. Figure 5 defines the rail head surface for decarburisation checks.

No closed ferrite network shall be observed below 0,6 mm depth measured anywhere on the rail-head surface.

9.1.5 Hardness

Brinell hardness tests shall be carried out in accordance with EN ISO 6506-1 at the frequency shown in Table 2. The test conditions shall be as follows:

— tungsten carbide ball;

— ball diameter 2,5 mm;

— load 1,839 kN;

— period of application 15 s.

Other measurement techniques, for example Rockwell or Vickers hardness testing, may be used, but in case of dispute Brinell hardness testing in accordance with EN ISO 6506-1 shall be used.

The hardness values measured shall meet the requirements given in Table 5 for the relevant grade.

In the case of the heat-treated rails, the following shall apply:

$HBW_2 > HBW_3 + 0{,}4(HBW_1 – HBW_3)$,

where HBW_1, HBW_2 and HBW_3 are the mean hardness values at position 1, 2 or 3, respectively. Also the difference between any of the three positions shall be no more than 30 HBW. The testing positions are shown in Figure 6.

The hardness on the centre line of the head crown shall not vary by more than 30 HBW on any individual rail.

0,6 mm shall be ground from the running surface before a hardness impression is made.

Table 5 — Hardness testing positions and requirements

[A1]

Position	Rail steel grade				
	R200	R220	R260	R320Cr	R350HT
	Hardness, HBW 2,5				
RS [a]	200 to 240	220 to 260	260 to 300	320 to 360	350 to 390 [b]
1	[c]	[c]	[c]	[c]	340 min.
2	[c]	[c]	[c]	[c]	331 min.
3	[c]	[c]	[c]	[c]	321 min.
4	[c]	[c]	[c]	[c]	340 min.

[a] RS = Point on the centre line running surface.

[b] If the hardness exceeds 390 HBW, the rail is acceptable provided the microstructure is confirmed to be pearlitic, and the hardness does not exceed 405 HBW.

[c] not relevant

[A1]

9.1.6 Tensile tests

9.1.6.1 General

The tensile test shall be carried out with the test frequency specified in Table 2. Test samples from the rail shall be taken as given in Figure 2. Results obtained shall comply with the values given in Table 3 a).

9.1.6.2 Method of test

The manufacturer shall determine the tensile properties in accordance with [A1] EN ISO 6892-1:2009 [A1] using a round tensile test piece with the dimensions as follows:

— diameter of 10 mm;

— original cross-sectional area of 78,5 mm^2;

— original gauge length of 50 mm;

— minimum parallel length of 55 mm.

Before testing at ambient temperature the tensile test pieces shall be maintained at a temperature of 200 °C for up to 6 h. In the case of dispute, before testing at ambient temperature the tensile test pieces shall be maintained at a temperature of 200 °C for 6 h.

9.1.7 Retest procedures

If any test fails to meet the requirements of 9.1.2 to 9.1.6 (but excluding hydrogen) then two tests shall be performed on samples from rails in close proximity to the original. Should either retest fail then rails shall be progressively tested until acceptable material is found. The failed material shall be rejected or in the case of heat treated material re-treated and tested. For hydrogen testing refer to 9.1.2.2.

9.2 Dimension tolerances

9.2.1 Profile

The nominal dimensions of the rail profile (see Annex A) and the actual dimensions anywhere on any rail shall not differ by more than the tolerances given in Table 6.

Table 6 — Profile tolerances

* Reference points (see EN 13674-1:2003, Annex E, Figure E.1)		Tolerances mm	Gauge figure number see EN 13674-1:2003, Annex E
Height of rail [a]	*H	+0,5/-1,0	E.3
Crown profile	*C	+0,6/-0,6	E.4
Width of rail head	*WH	+0,6/-0,5	E.5
Rail asymmetry	*As	±1,2	E.6, E.7
Inclination of fishing surfaces (on the basis of 14 mm parallel) to the inclined theoretical fishing surfaces) [b]	*IF	±0,35	E.8
Height of fishing	*HF	+0,5/-1,0	E.8
Web thickness	*WT	+1,0/-0,5	E.9
Width of rail foot	*WF	+1,5/-1,0	E.10
Foot base concavity		0,5 max.	

[a] The total height variation in any one rail shall not be greater than 1 mm.

[b] The maximum fishing tolerance on the head and on the foot is ±0,35 mm but the total tolerance allowed is also ±0,35 mm.

9.2.2 Straightness and twist

Tolerances for straightness and twist shall meet the requirements in Table 7.

Table 7 — Straightness and twist

Dimensional property	Rail position	Requirement
Vertical and horizontal flatness	Body	≤ 0,7 mm over 1,5 m
Vertical and horizontal straightness	End	≤ 1,5 mm, measured as a maximum ordinate on a chord of 1,5m
Upsweep/downsweep	Whole rail	10 mm [a]
Sidesweep		Not to be measured
Twist		If the rail shows evidence of twist being laid head up on an inspection bed, it shall be checked by inserting feeler gauges between the base of the rail and the rail skid nearest the rail end. If the gap exceeds 2,5 mm the rail shall be rejected. (See Figure 7)

[a] The ends of the rails shall not be up more than 10 mm when the rail is on its foot or on its head when standing on an inspection bed.

9.2.3 Cutting and drilling

The size and location of drilled holes, the squareness of rail ends and rail lengths shall be within the tolerances given in Table 8.

Drilled holes and rail ends shall be de-burred. For holes that are to be subject to special treatments, the tolerances shall be specified(see Clause 4 f)).

9.3 Gauges

The gauges are as shown in EN 13674-1:2003, Annex E.

Other measurement techniques may be used; in the case of dispute, those in EN 13674-1:2003, Annex E shall be used.

9.4 Inspection for internal quality and surface quality

9.4.1 internal quality

9.4.1.1 All rails above 39 kg/m shall be ultrasonically tested by an automated process ensuring that the rail length and specified cross-sectional area are inspected, leaving only a very small area untested. Untested ends shall be tested by an appropriate procedure or cropped off.

9.4.1.2 The minimum cross-sectional area examined by the ultrasonic technique shall be:

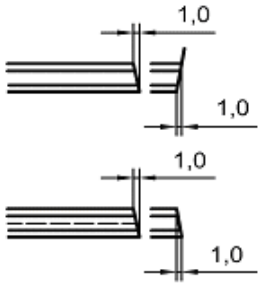
— at least 70 % of the head;

— at least 60 % of the web;

— area of the foot specified in Figure 11.

By convention these areas are based on projecting the nominal crystal size of the probe. On request of the purchaser, the manufacturer shall demonstrate that all the specified areas (see above) are covered with the used procedure. The head shall be tested from both sides and from the running surface.

Table 8 — Drilling and cutting tolerances

Number	Dimensional requirement	Tolerance
1	Drilling diameter ≤ 30 mm > 30 mm Centring and positioning of the holes vertically and horizontally	 ± 0,5 mm ± 0,7 mm The horizontal position of the holes is checked using a gauge as shown in Figure E.12 of EN 13674-1:2003, Annex E which has a stop designed to come into contact with the end of the rail and pins designed to enter the holes The diameter of the pins for horizontal and vertical clearances is smaller than the diameter of the holes by - 1,0 mm for holes less than or equal to 30 mm in diameter - 1,4 mm for holes greater than 30 mm in diameter [A1] *deleted text* [A1] the distances between the centre lines of the pins and the stop are equal to the nominal distances from the centre line of the holes to the end of the rail [A1] *deleted text* [A1] the gauge pins shall be able to enter the holes at the same time while the stop is touching the end of the rail The vertical centring of the holes can be checked using a gauge as shown in Figure E.13 of EN 13674-1:2003, Annex E The side of the hole, left or right, is determined by proceeding from the side with the relief markings
2	Squareness of ends	1,0 mm in any direction 
3	Length [a] - both ends drilled [A1] ≤ 24 m [A1] > 24 m ≤ 40 m - other (un-drilled or one end drilled)	 ± 3 mm ± 4 mm ± 1 mm/per metre of rail (max. ± 30 mm on any rail) For special purpose un-drilled rails the length tolerance is ± 6 mm

[a] The given rail lengths apply for +15 °C. Measurements made at other temperatures are to be corrected to take into account expansion or contraction of the rail.

9.4.1.3 The sensitivity levels of the automatic equipment used shall be a minimum 4 dB greater than the level required to detect the reference reflectors described in 9.4.1.4. After calibration with the reference reflectors, the signal-to-noise ratio of the automated equipment shall be at least 10 dB. A rail giving an echo referring to a possible defect shall be separated by means of an automatic trigger/alarm level combined with a marking and/or sorting system. For possible retesting, the test sensitivity shall be increased to 6 dB instead of 4 dB.

Rails giving signals over the threshold in the rail using the increased sensitivity shall be rejected or cut back to remove the defective portion.

The system shall incorporate continuous monitoring of interface and, if present, backwall echo signals.

9.4.1.4 There shall be a calibration rail for each profile ultrasonically tested and the positions of the reference reflectors are given for the rail-head, web and foot of the 60E1 profile in Figures 8, 9 and 10 respectively. Calibration rails for other profiles with reference reflectors similar to those in accordance with Figures 8 to 10 for 60E1 shall be available, and on request detailed drawings shall be presented to the purchaser.

Other methods of calibration may be used but these methods shall be equivalent to that described above.

9.4.2 Surface quality

9.4.2.1 Requirements

a) Hot marks, protrusions and seams

Protrusions on the running surface or the underside of the foot and any protrusions affecting the fit of the fishplate at less than 1 m from the extremity of the delivered rail shall be dressed to shape.

The depth of hot marks and seams, as defined in EN 10163-1, shall not exceed:

— 0,35 mm for the running surface;

— 0,5 mm for the rest of the rail.

In the case of longitudinal guide 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. Recurring guide marks along the same axis are accepted as a single guide mark.

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

In the case of hot-formed marks originating from the vicinity of the mill rolls, those which are recurrent along the same axis, at a distance equal to the roll circumference, shall be accepted as a single mark. They can be removed by dressing except those marks on the rail crown where a maximum of 3 per 40 m is allowed.

b) Cold marks

Cold marks are longitudinal or transverse cold-formed scratches.

The discontinuity depth shall be not larger than:

— 0,3 mm for the rail running surface and underside of foot;

— 0,5 mm for the rest of rail.

NOTE It is difficult, or impossible to detect in track fatigue cracks initiating and propagating from the underside of the foot; therefore all practicable efforts are to be made to avoid cold transverse marks in this area.

c) Surface microstructural damage

Any sign of surface microstructural damage resulting in martensite or white phase is not permitted.

9.4.2.2 Inspection on surface imperfections

a) General inspection

All rails shall be visually or automatically inspected on all faces for surface imperfections. In addition, the underside of the rail foot shall be inspected automatically in accordance with 9.4.2.2 b). All rails shall comply with the acceptance criteria defined in 9.4.2.1. Dressing of imperfections shall be in accordance with 9.4.2.3.

b) Automatic foot inspection

The rail shall be automatically inspected on the underside of the foot along its entire length.

The equipment used shall be able to detect test imperfections with sizes as shown in Table 9. The imperfections shall have a tolerance of ±0,1 mm.

Table 9 — Dimensions of test imperfections

Dimensions in millimetres

Depth	Length	Width
1,0	20	0,5
1,5	10	0,5

An edge loss for the automatic technique is permitted for the extreme 5 mm of the flat portion of the foot width at each side.

c) Checking of automatic and other testing equipment

The calibration rail shall be used to test the equipment at production speed at the beginning and once every 8 h of testing a particular profile.

9.4.2.3 Dressing of surface imperfections

a) Imperfections exceeding the limits specified in 9.4.2.1 a) to 9.4.2.1 c) shall be dressed out. Any protrusions affecting the fit of the fishplate (see 9.4.2.1 a)) shall be dressed to shape.

   If the imperfection depth cannot be measured it shall be investigated by depth proving, and subsequently dressed to the criteria below, using a rotary burr, lamellar flap tool or grinding belt, providing the rail microstructure is not affected by the operation and the work is contour blended.

   The depth of dressing shall be not larger than:

   — 0,35 mm for the rail running surface;

   — 0,5 mm for the rest of rail.

   No more than three defects within a length of 10 m of rail and, over the whole length, a maximum of one defect per 10 m rail length shall be dressed or proved. After dressing profile tolerances shall be in accordance with Table 6 and flatness tolerances shall be in accordance with Table 7.

b) Any sign of surface microstructural damage resulting in martensite or white phase shall be dressed or the rail rejected. The dressed area shall be proved by suitable hardness testing. The hardness shall not be more than 50BW greater than the surrounding material.

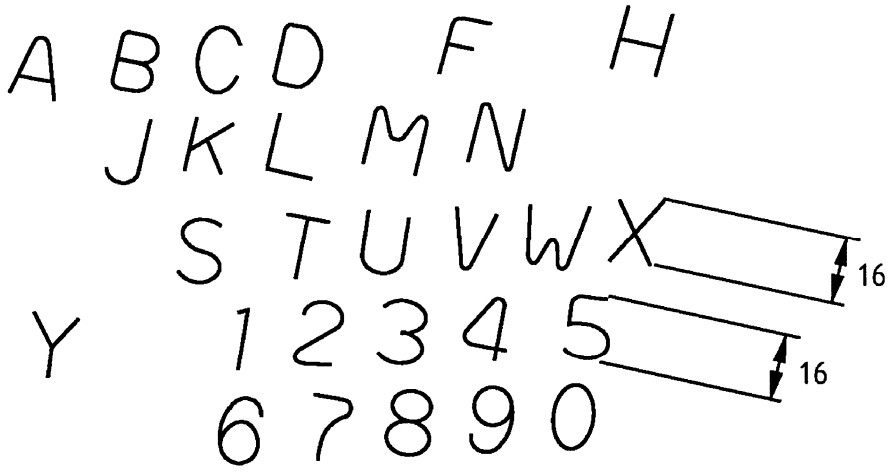
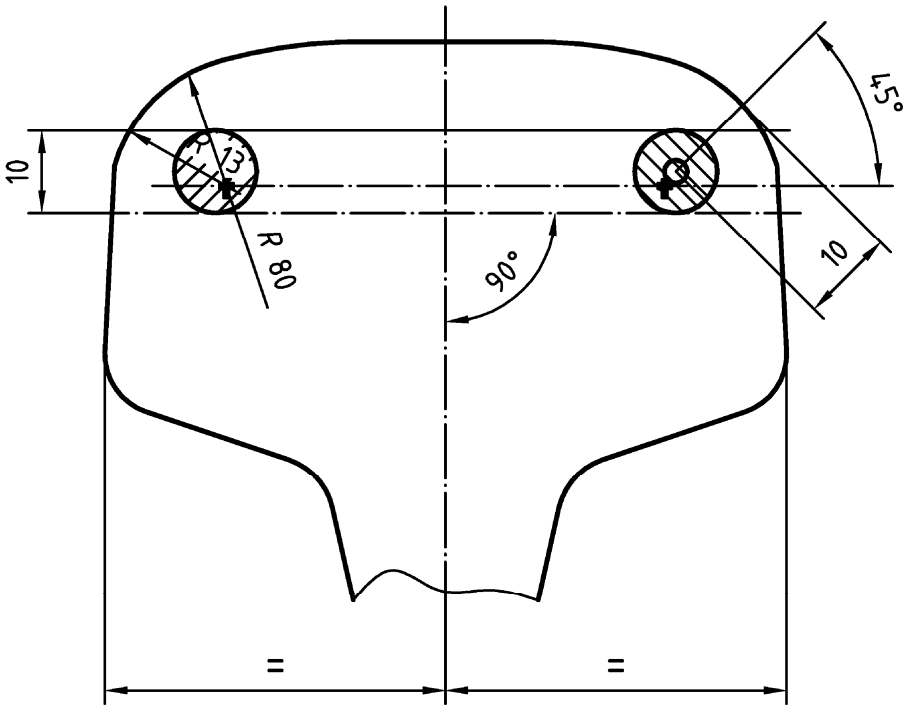


Figure 1 — Design of letters and numbers on a 10° angle for rail stamps

Dimensions in millimetres



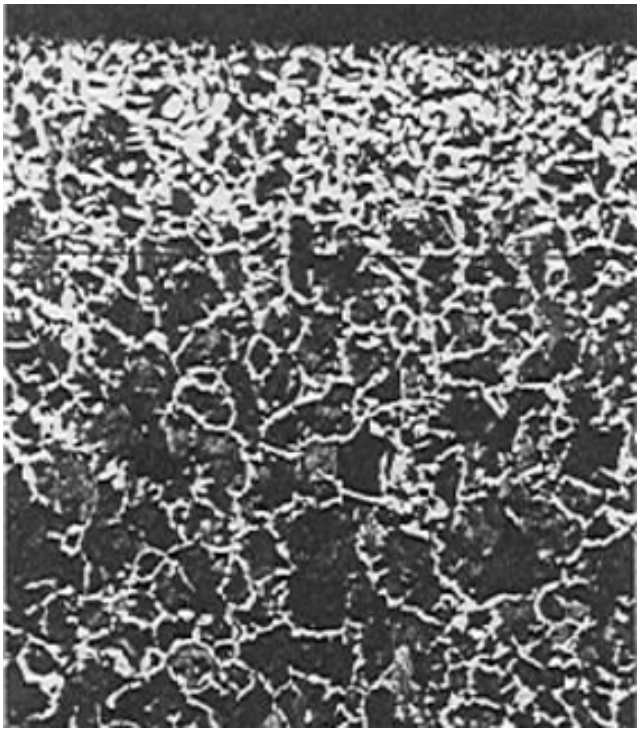
Key

- intersecting point of the R 13 and R 80 (60E1 profile)
- location at the centre of the tensile test piece
- area to be checked for microstructure

Figure 2 — Location of tensile test piece and microstructure checks

Photomicrograph x 500

Figure 3 — Photomicrograph and diagram showing maximum allowable ferrite at the grain boundaries for grades other than R200 and R220



← Surface of rail

← Limit of continuous ferrite network. This example shows decarburisation to a depth of 0,28 mm

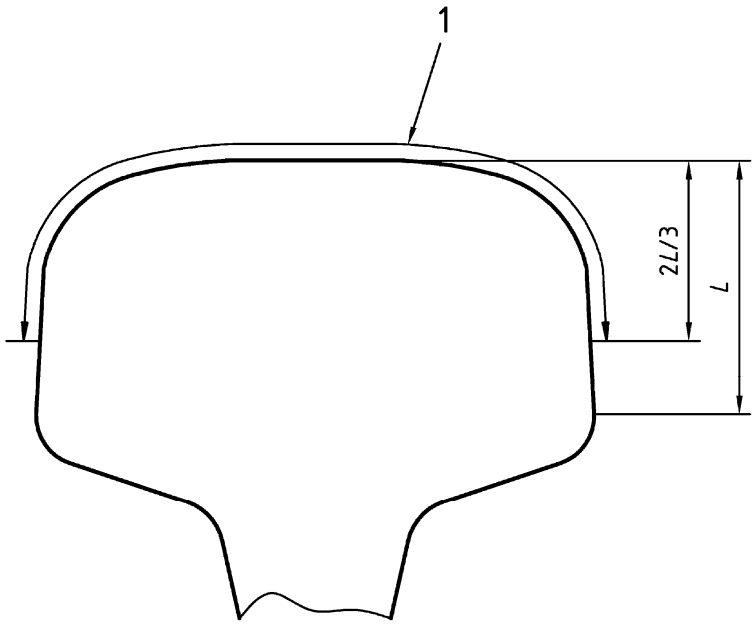
Grades R200 and R220

← Surface of rail

← Limit of continuous ferrite network. This example shows decarburisation to a depth of 0,28 mm

All grades other than R200 and R220

Figure 4 — Photomicrographs (x 100) showing depth of decarburisation allowed on the rail wear surface

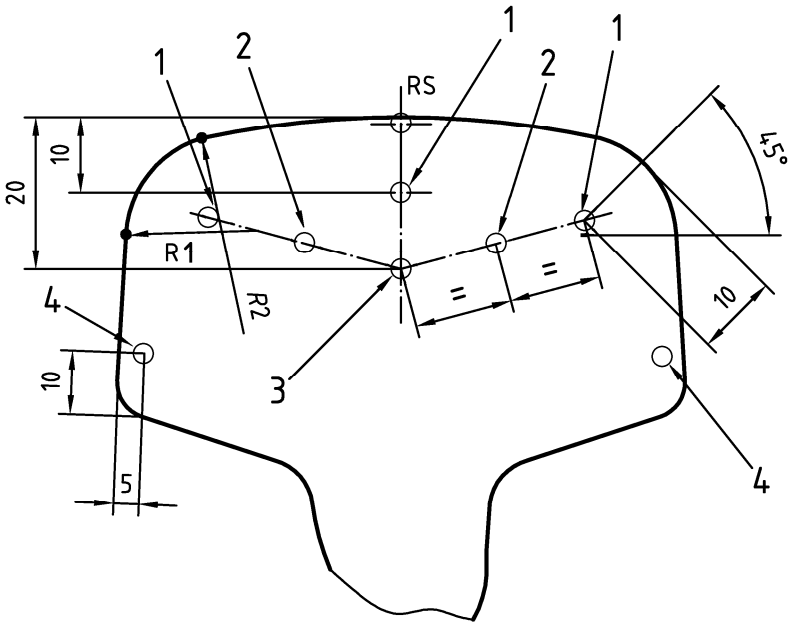


Key

1 decarburisation limits apply to this part of rail-head

Figure 5 — Range of extent of rail-head surface for decarburisation checks

Dimensions in millimetres



Key

1, 2, 3 and 4 location of hardness testing (see Table 5)

- exact intersecting points of the radii

Figure 6 — Hardness testing positions

Dimensions in millimetres

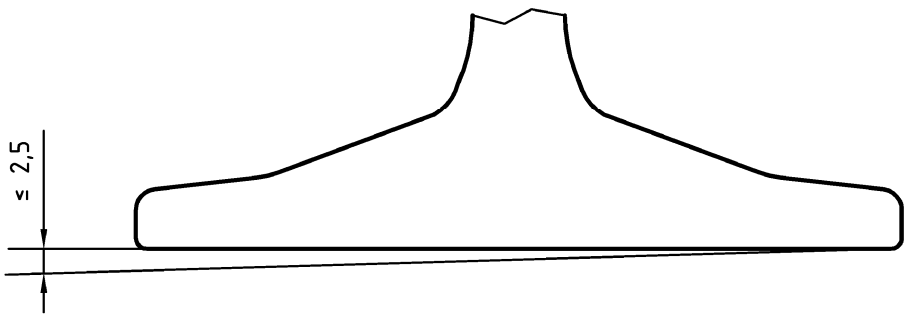
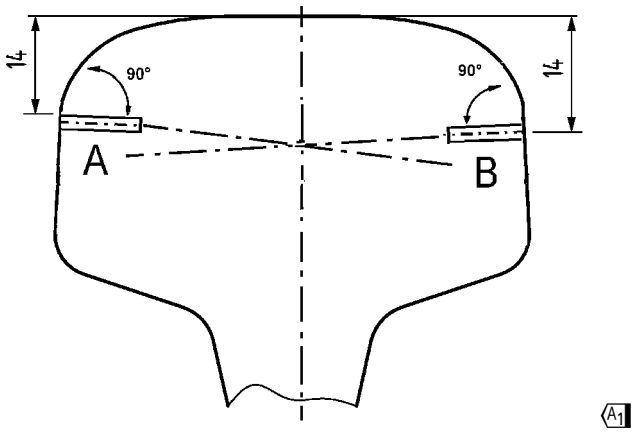


Figure 7 — Whole rail twist

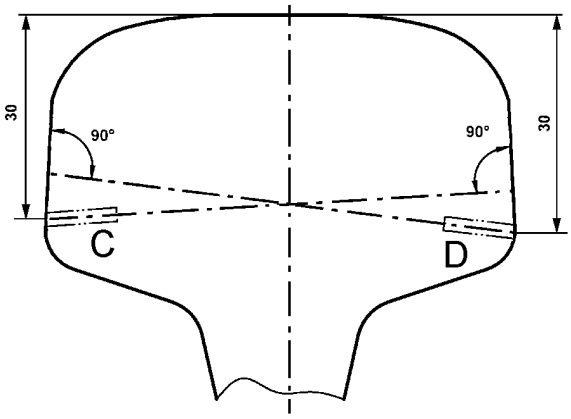
Dimensions in millimetres

[A1]



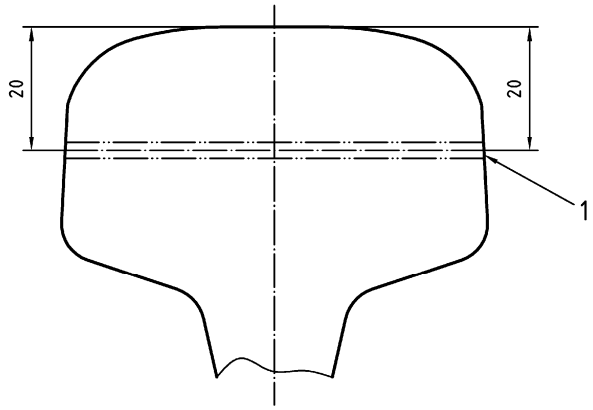
[A1]

NOTE 1 Both flat bottomed holes are 2 mm diameter and 15 mm deep.



NOTE 2 Both flat-bottomed holes are 2 mm diameter and 15 mm deep.

NOTE 3 A smaller distance than 30 mm may be agreed where necessary in the case of smaller profiles.

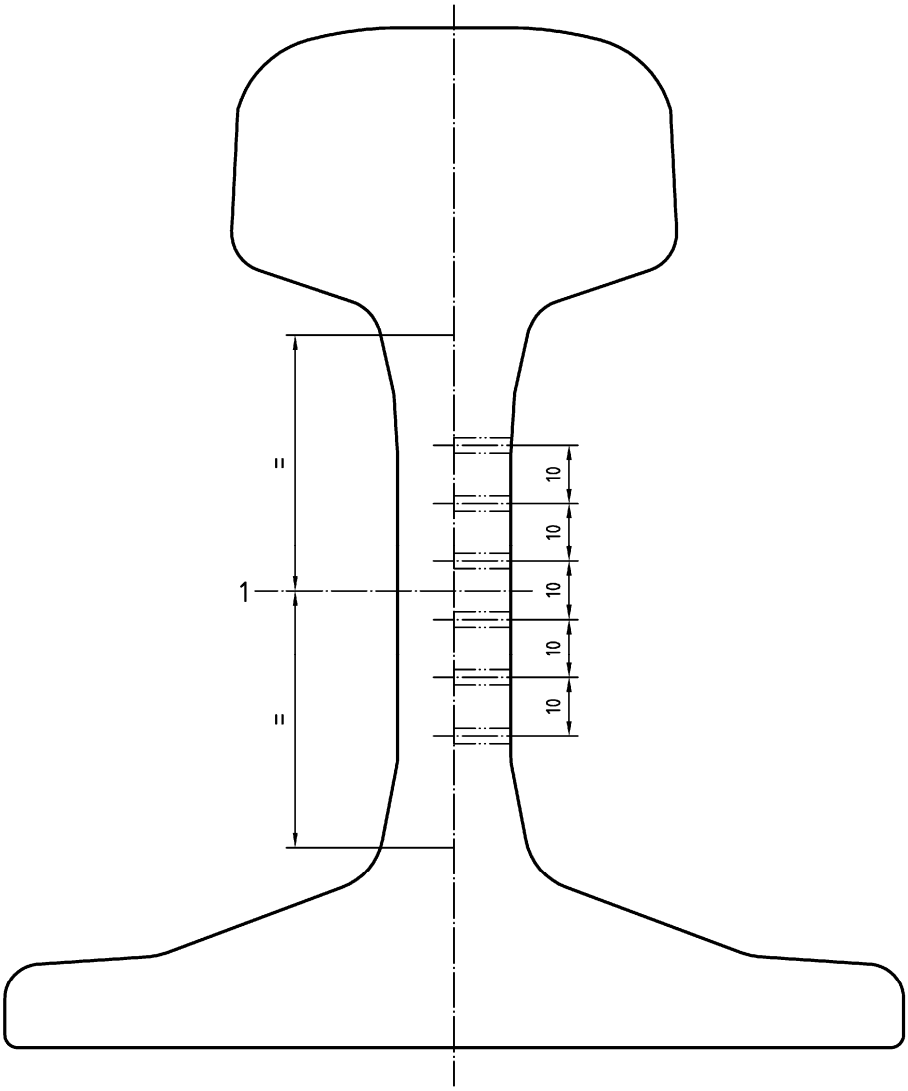


Key

1 2 mm diameter through hole

Figure 8 — Location of artificial defects in rail-head

Dimensions in millimetres
measured from the centre line



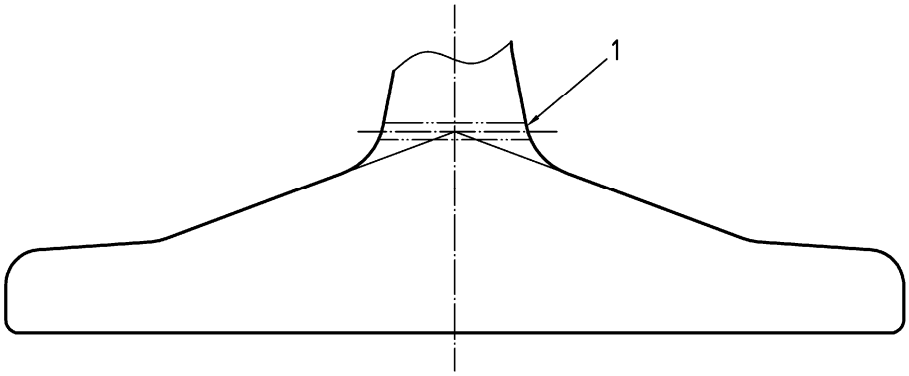
Key

1 centreline of web

NOTE 1 Flat-bottomed holes are 2 mm diameter drilled to centre line of web.

NOTE 2 Flat-bottomed holes are allowed to be ±1° from horizontal.

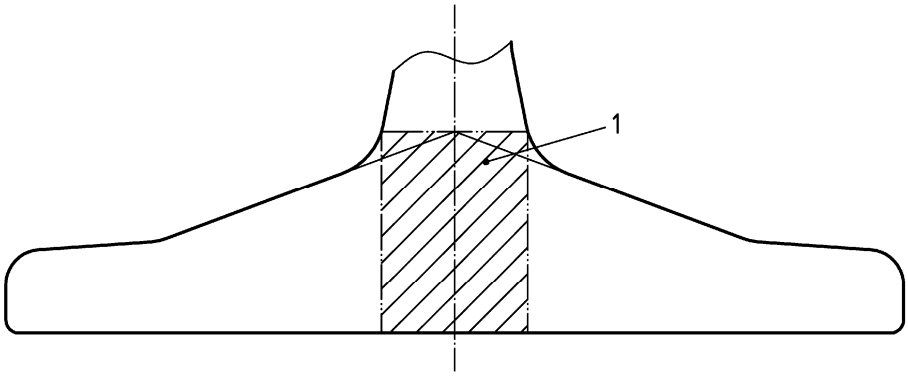
Figure 9 — Location of artificial defects in rail web



Key

1 2 mm diameter through hole

Figure 10 — Location of artificial defect in rail foot



Key

1 area to be tested

Figure 11 — Area to be tested in rail foot

Annex A
(normative)

Rail profiles

The rail profiles listed are new designated and accurately dimensioned profiles developed from the previous less accurately dimensioned profiles listed. Table A.2 and Figure A.14 define the rail transition references.

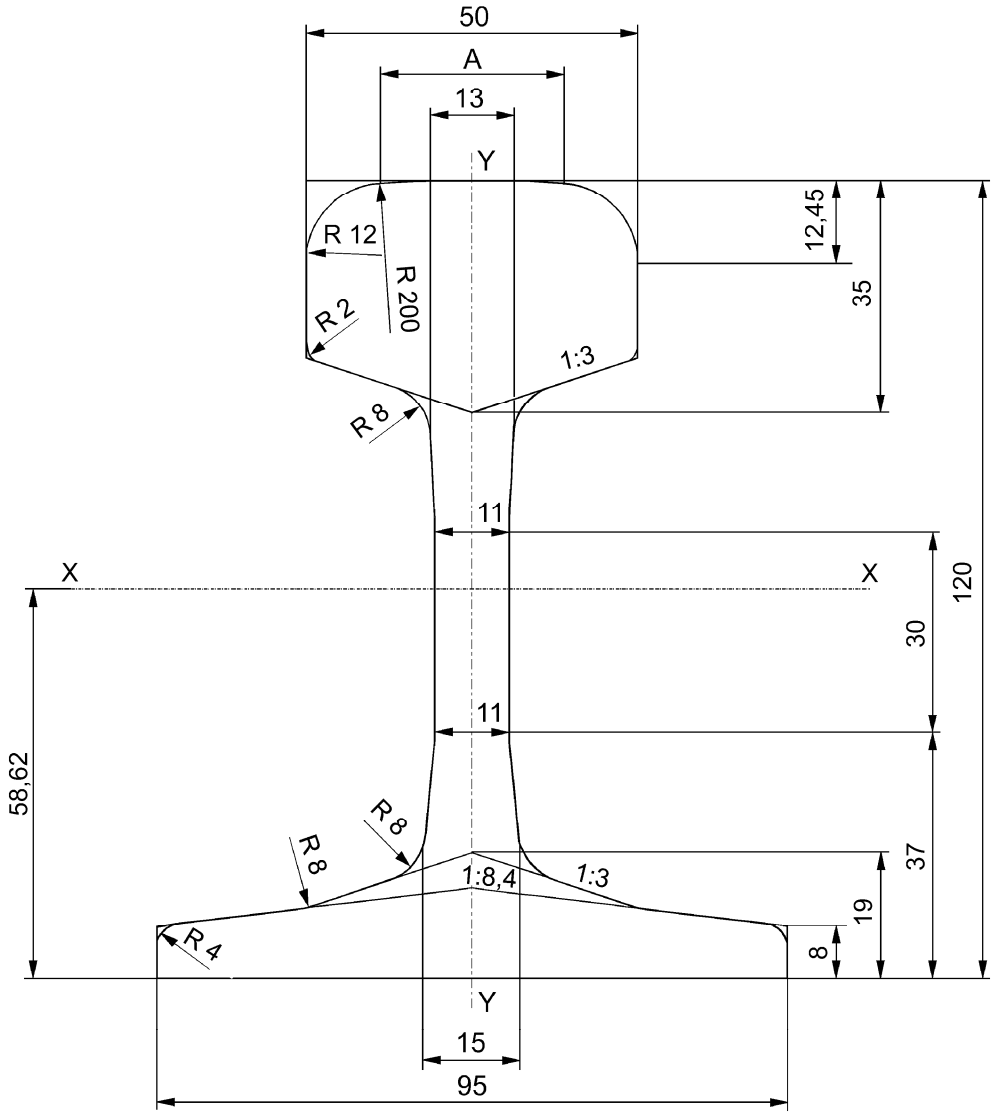
Table A.1 — List of profiles and previous rail profiles

Figure No.	Profile	Previous profile
A.1	27E1	27 UNI
A.2	30E1	S 30
A.3	30E2	BS 60A
A.4	33E1	S 33
A.5	35E1	Xa
A.6	36E1	36 UNI
A.7	36E2	36 kg (S-40)
A.8	36E3	VST 36
A.9	39E1	BS 80A
A.10	40E1	S41 R14
A.11	41E1	S41 R10
A.12	43E1	K43S
A.13	45E1	BS 90A
A.14	45E2	DSB 45

Table A.2 — Rail transition points

Figure No.	Profile	Previous profile
A.15	**Principal rail transition references**	
A.16	27E1	27 UNI
A.17	30E1	S 30
A.18	30E2	BS 60A
A.19	33E1	S 33
A.20	35E1	Xa
A.21	36E1	36 UNI
A.22	36E2	36 kg (S-40)
A.23	39E1	BS 80A
A.24	40E1	S41 R14
A.25	41E1	S41 R10
A.26	43E1	K43S
A.27	45E1	BS 90A
A.28	45E2	DSB 45

Dimensions in millimetres



Key

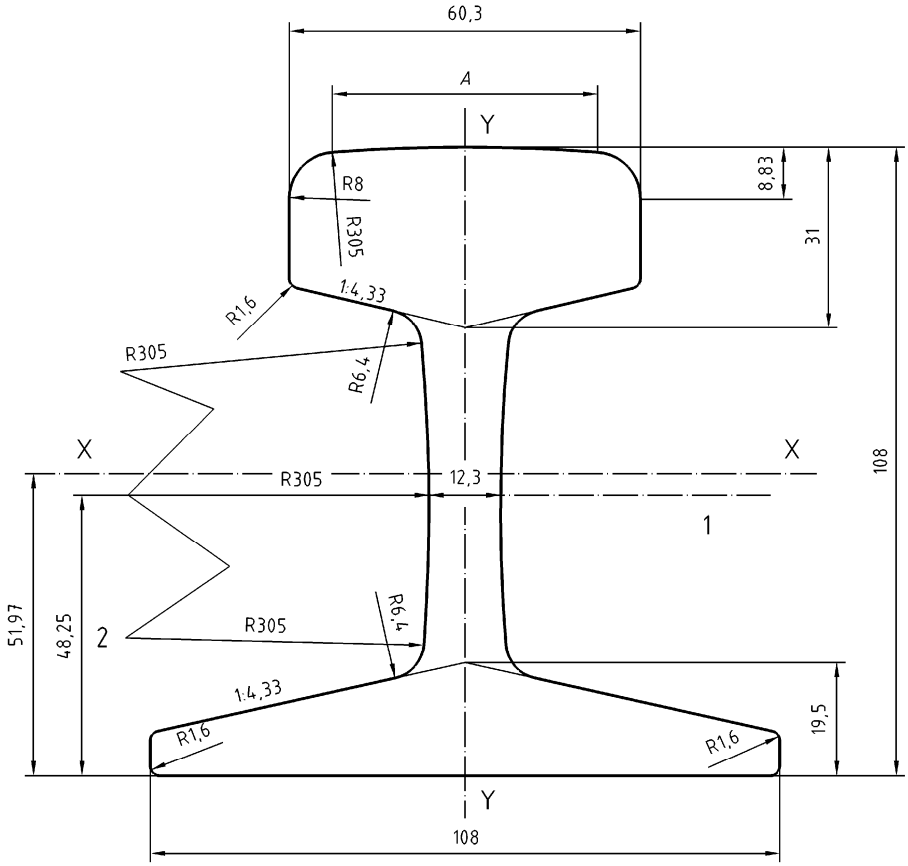
1 centre line of branding

Cross-sectional area	:	34,47	cm^2
Mass per metre	:	27,06	kg/m
Moment of inertia x-x axis	:	666,5	cm^4
Section modulus-Head	:	108,6	cm^3
Section modulus-Base	:	113,7	cm^3
Moment of inertia y-y axis	:	95,0	cm^4
Section modulus y-y axis	:	20,0	cm^3

Indicative dimensions : A = 27,666 mm

Figure A.1 — Rail profile 27E1

Dimensions in millimetres



Key

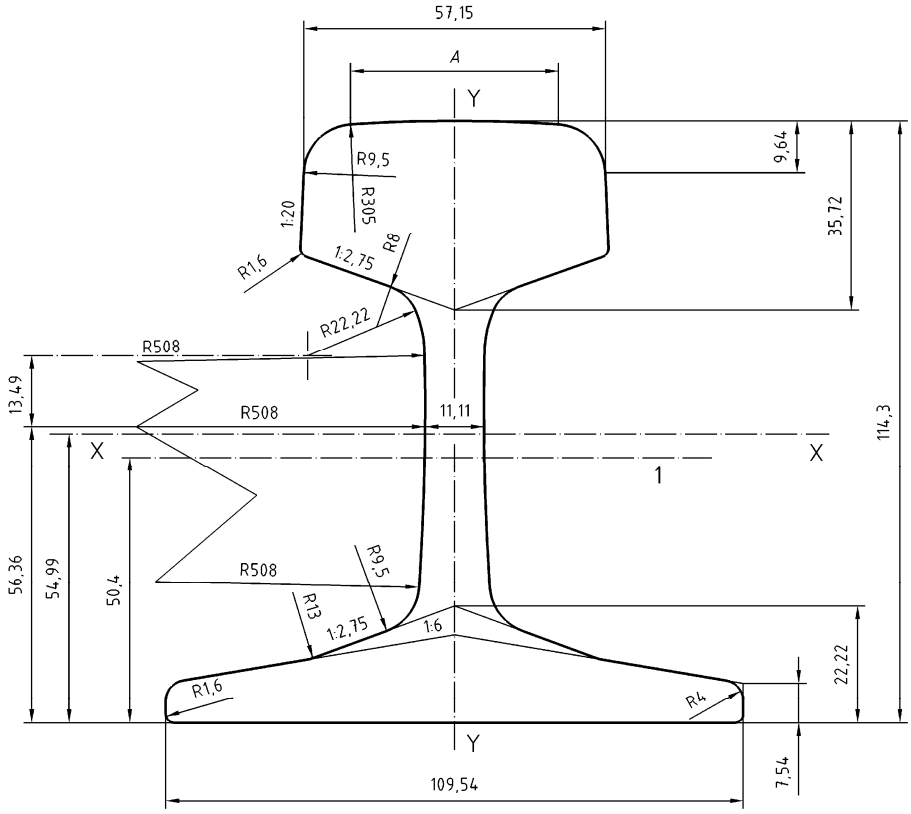
1 centre line of branding

Cross-sectional area	:	38,39	cm^2
Mass per metre	:	30,13	kg/m
Moment of inertia x-x axis	:	608,2	cm^4
Section modulus-Head	:	108,5	cm^3
Section modulus-Base	:	117,0	cm^3
Moment of inertia y-y axis	:	150,9	cm^4
Section modulus y-y axis	:	27,9	cm^3

Indicative dimensions : A = 45,493 mm

Figure A.2 — Rail profile 30E1

Dimensions in millimetres



Key

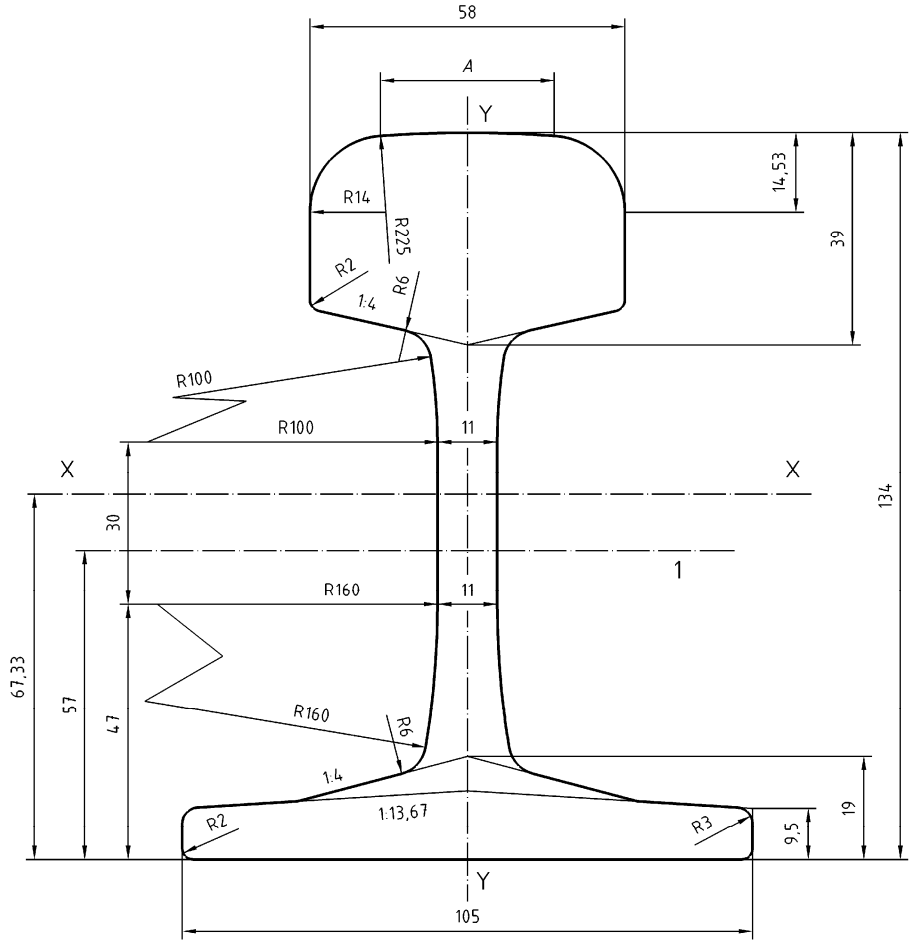
1 centre line of branding

Cross-sectional area	:	39,00	cm^2
Mass per metre	:	30,62	kg/m
Moment of inertia x-x axis	:	695,9	cm^4
Section modulus-Head	:	117,3	cm^3
Section modulus-Base	:	126,5	cm^3
Moment of inertia y-y axis	:	149,9	cm^4
Section modulus y-y axis	:	27,4	cm^3

Indicative dimensions : A = 39,401 mm

Figure A.3 — Rail profile 30E2

Dimensions in millimetres



Key

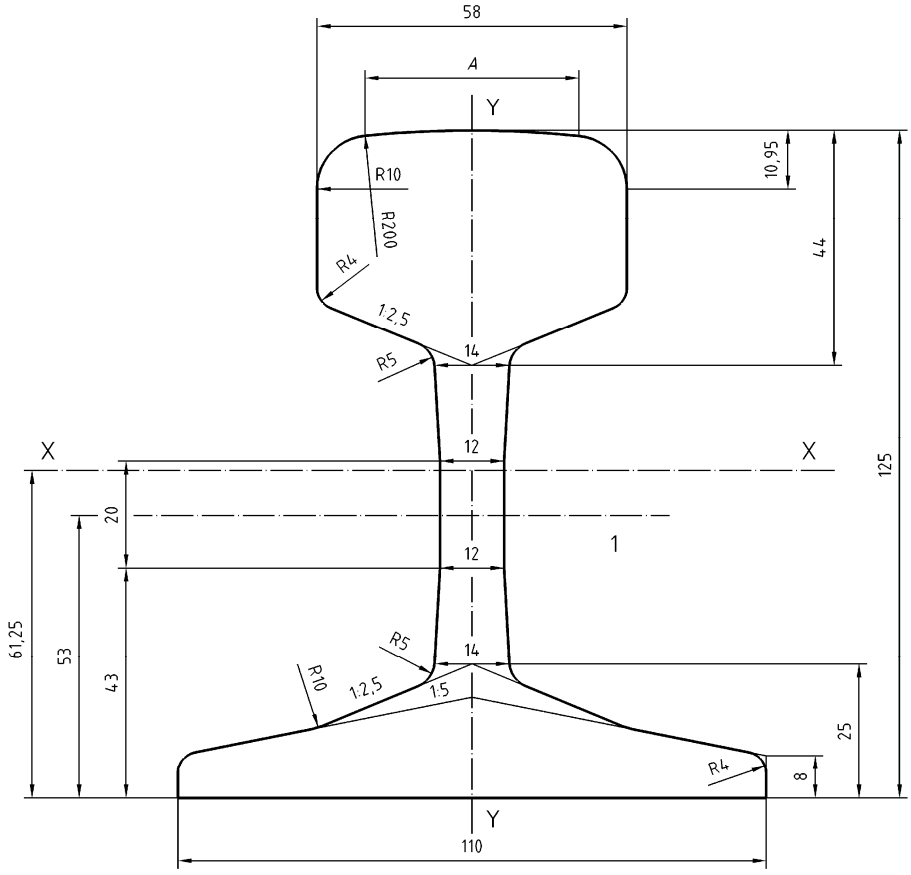
1 centre line of branding

Cross-sectional area	:	42,64	cm^2
Mass per metre	:	33,47	kg/m
Moment of inertia x-x axis	:	1 040,3	cm^4
Section modulus-Head	:	156,0	cm^3
Section modulus-Base	:	154,5	cm^3
Moment of inertia y-y axis	:	151,9	cm^4
Section modulus y-y axis	:	28,9	cm^3

Indicative dimensions : A = 31,991 mm

Figure A.4 — Rail profile 33E1

Dimensions in millimetres



Key

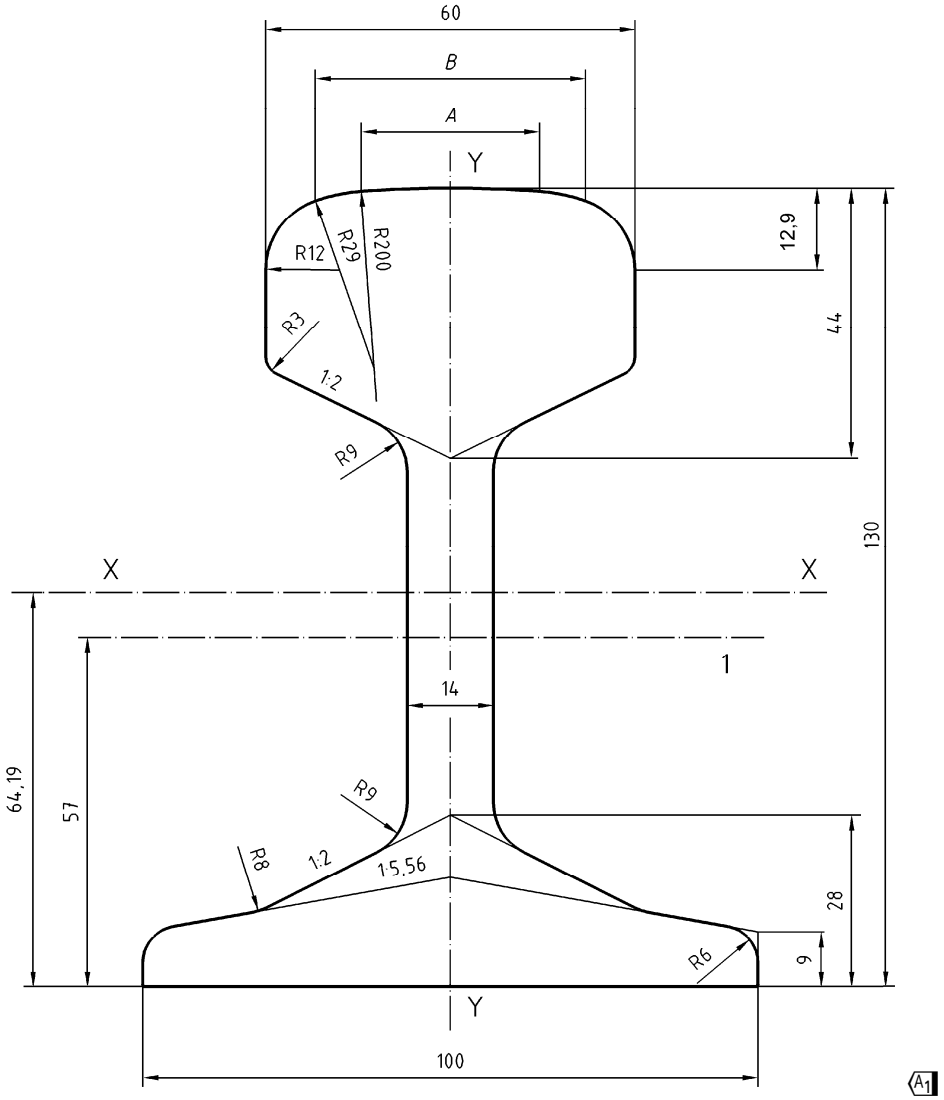
1 centre line of branding

Cross-sectional area	:	45,55	cm^2
Mass per metre	:	35,76	kg/m
Moment of inertia x-x axis	:	936,3	cm^4
Section modulus-Head	:	146,9	cm^3
Section modulus-Base	:	152,9	cm^3
Moment of inertia y-y axis	:	174,5	cm^4
Section modulus y-y axis	:	31,7	cm^3

Indicative dimensions : A = 40,000 mm

Figure A.5 — Rail profile 35E1

Dimensions in millimetres



Key

1 centre line of branding

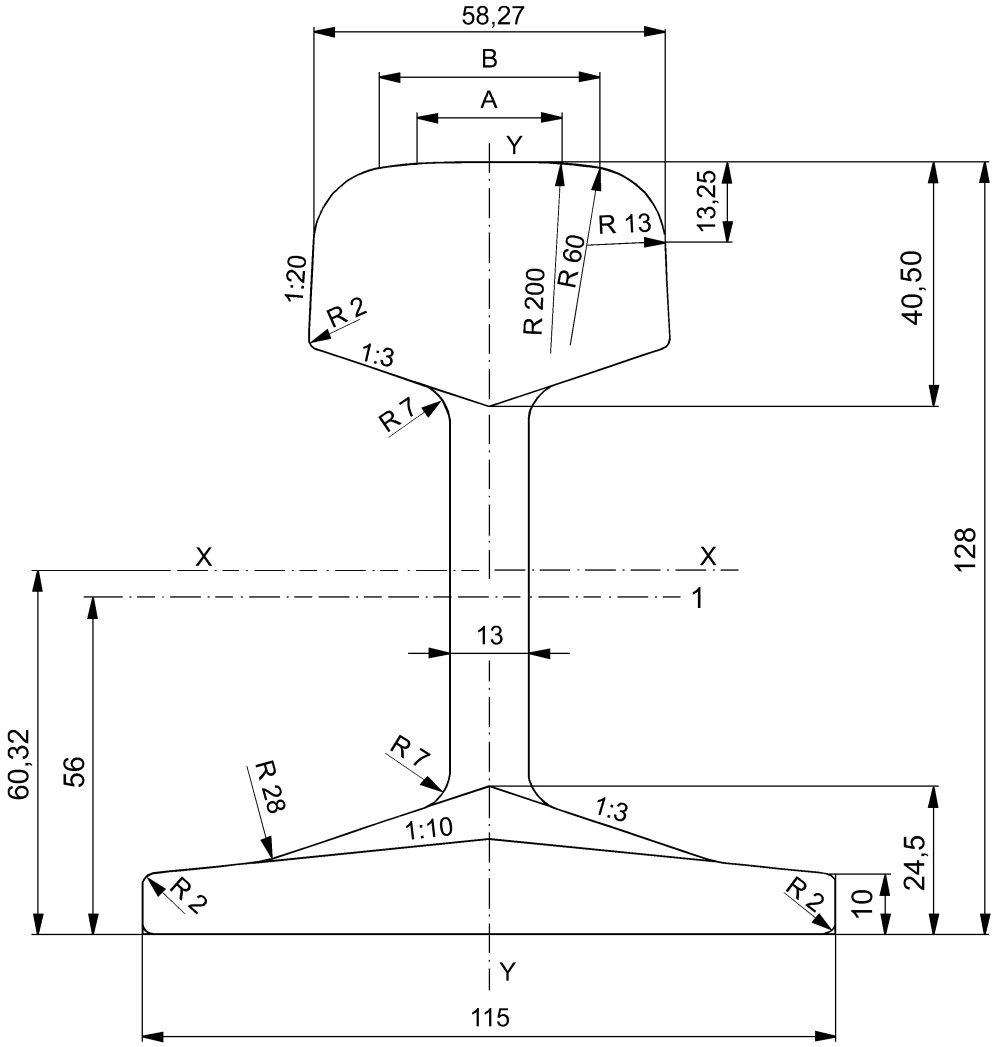
Cross-sectional area	:	46,19	cm^2
Mass per metre	:	36,26	kg/m
Moment of inertia x-x axis	:	1 012,1	cm^4
Section modulus-Head	:	153,8	cm^3
Section modulus-Base	:	157,7	cm^3
Moment of inertia y-y axis	:	150,1	cm^4
Section modulus y-y axis	:	30,0	cm^3

Indicative dimensions : A = 28,998 mm
B = 43,911 mm

Figure A.6 — Rail profile 36E1

Dimensions in millimetres

A1



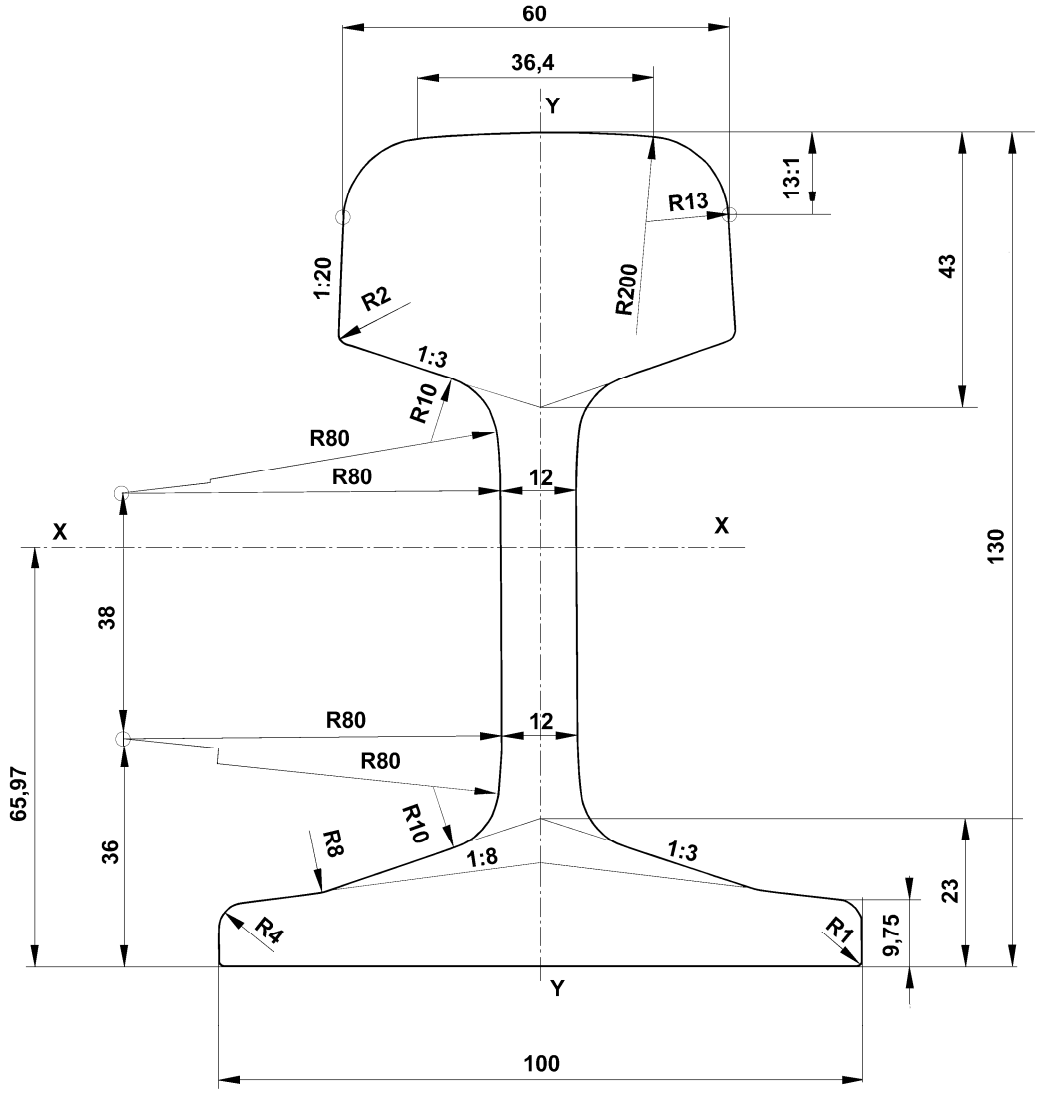
Key
1 centre line of branding

Cross-sectional area	:	46,61	cm^2
Mass per metre	:	36,59	kg/m
Moment of inertia x-x axis	:	1020,1	cm^4
Section modulus - Head	:	150,7	cm^3
Section modulus - Base	:	169,1	cm^3
Moment of inertia y-y axis	:	202,7	cm^4
Section modulus y-y axis	:	35,3	cm^3

Indicative dimensions : A = 23,912 mm
B = 36,607 mm

Figure A.7 — Rail profile 36E2 A1

Dimensions in millimetres

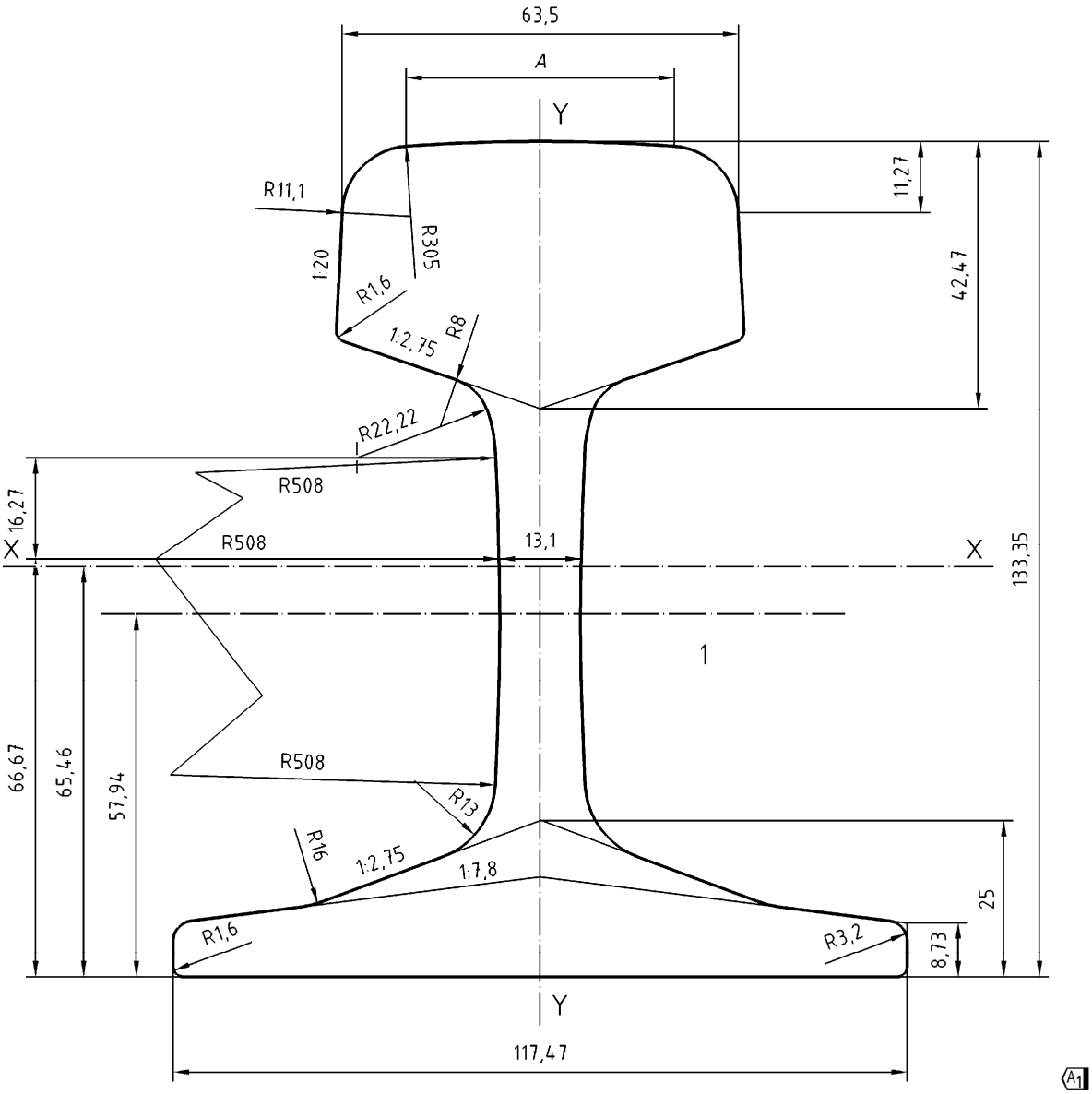


Key

Mass	:	35.82	Kg/m
Area	:	45.63	cm^2
Moment of inertia x-x axis	:	1009.3	cm^4
Moment of inertia y-y axis	:	157.7	cm^4
Section modulus x-x - Head	:	157.6	cm^3
Section modulus x-x - Base	:	153.0	cm^3
Section modulus y-y axis	:	31.5	cm^3

Figure A.8 — Rail profile 36E3

Dimensions in millimetres



Key

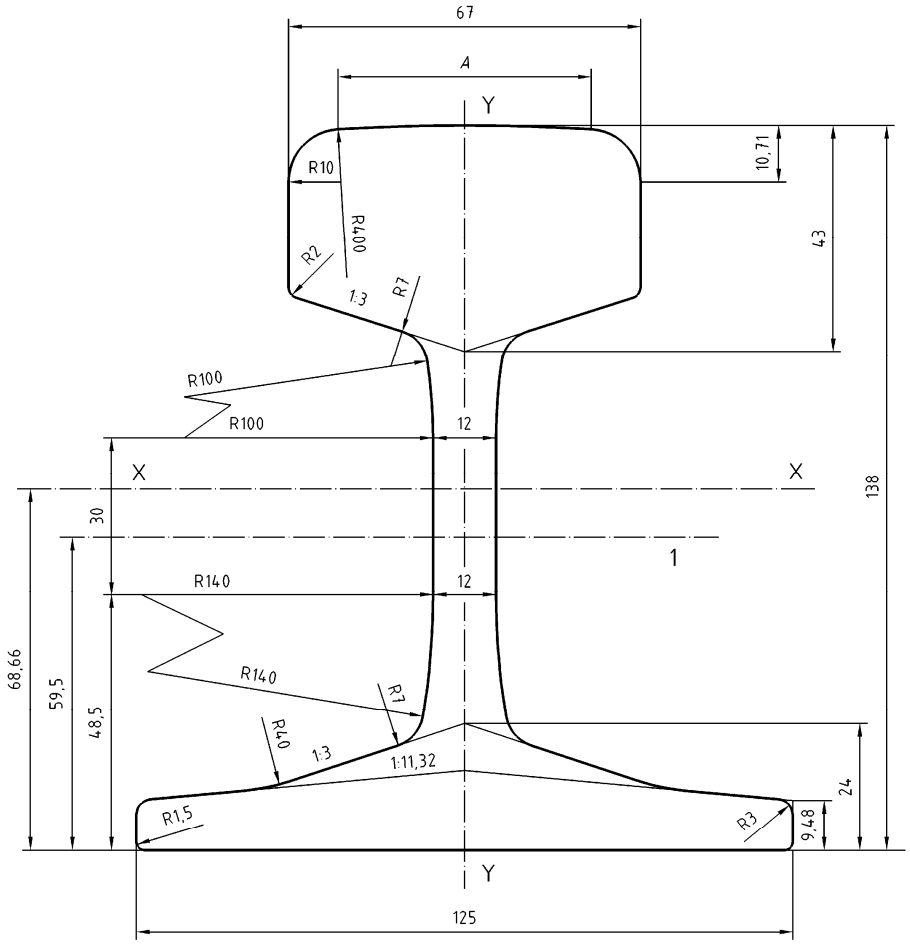
1 centre line of branding

Cross-sectional area	:	50,66	cm^2
Mass per metre	:	39,77	kg/m
Moment of inertia x-x axis	:	1 204,9	cm^4
Section modulus-Head	:	177,8	cm^3
Section modulus-Base	:	184,1	cm^3
Moment of inertia y-y axis	:	219,6	cm^4
Section modulus y-y axis	:	37,4	cm^3

Indicative dimensions : A = 42,889 mm

Figure A.9 — Rail profile 39E1

Dimensions in millimetres



Key

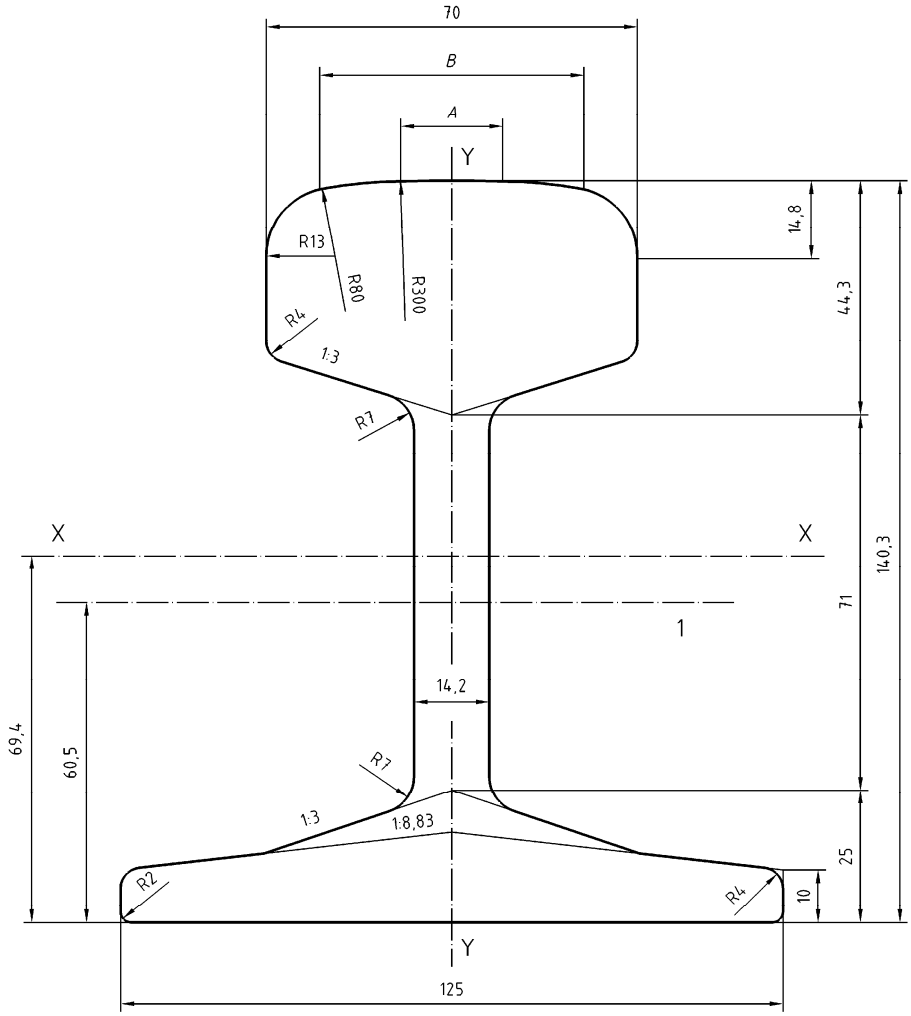
1 centre line of branding

Cross-sectional area	:	52,17	cm^2
Mass per metre	:	40,95	kg/m
Moment of inertia x-x axis	:	1 366,9	cm^4
Section modulus-Head	:	195,9	cm^3
Section modulus-Base	:	200,4	cm^3
Moment of inertia y-y axis	:	262,1	cm^4
Section modulus y-y axis	:	41,9	cm^3

Indicative dimensions : A = 40,414 mm

Figure A.10 — Rail profile 40E1

Dimensions in millimetres



Key

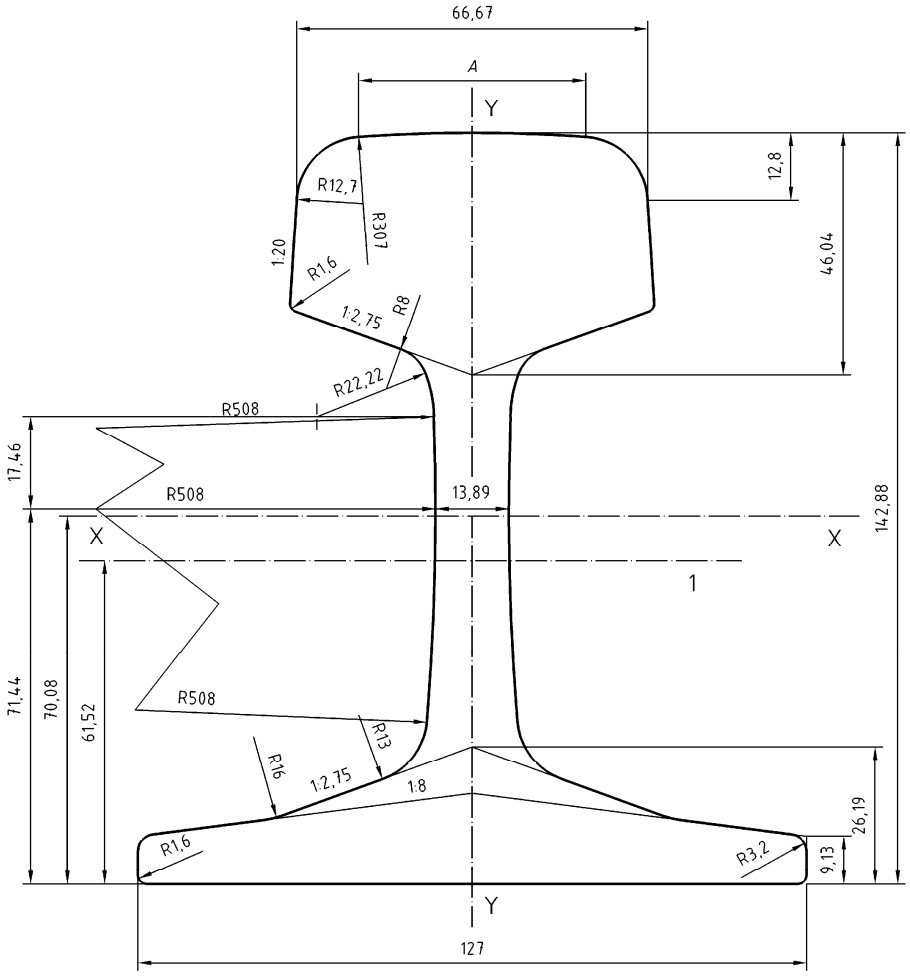
1 centre line of branding

Cross-sectional area	:	52,53	cm^2
Mass per metre	:	41,24	kg/m
Moment of inertia x-x axis	:	1 382,1	cm^4
Section modulus-Head	:	199,3	cm^3
Section modulus-Base	:	201,3	cm^3
Moment of inertia y-y axis	:	265,3	cm^4
Section modulus y-y axis	:	42,4	cm^3

Indicative dimensions : A = 48,205 mm

Figure A.11 — Rail profile 41E1

Dimensions in millimetres



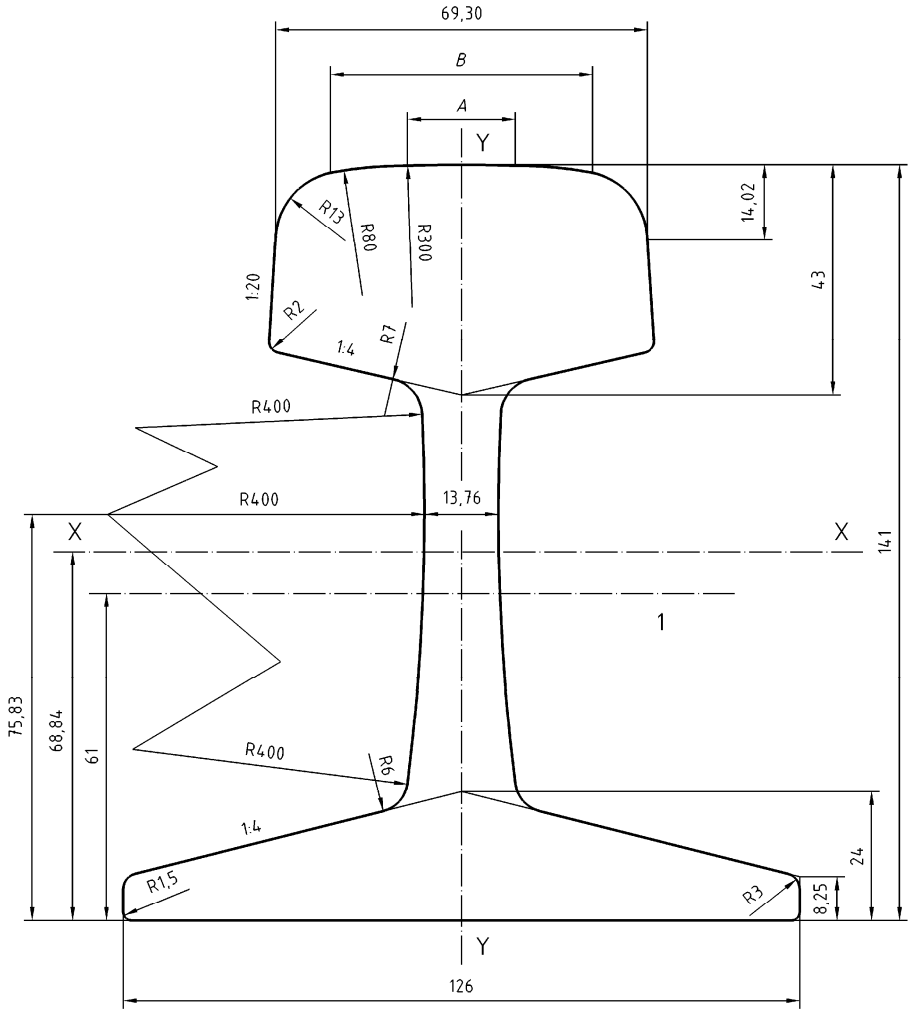
Key

1 centre line of branding

Cross-sectional area	:	55,84	cm^2
Mass per metre	:	43,84	kg/m
Moment of inertia x-x axis	:	1 478,7	cm^4
Section modulus - Head	:	208,6	cm^3
Section modulus - Base	:	213,1	cm^3
Moment of inertia y-y axis	:	286,3	cm^4
Section modulus y-y axis	:	45,8	cm^3
Indicative dimensions :	A = 19,258		
	B = 49,797		

Figure A.12 — Rail profile 43E1

Dimensions in millimetres



Key

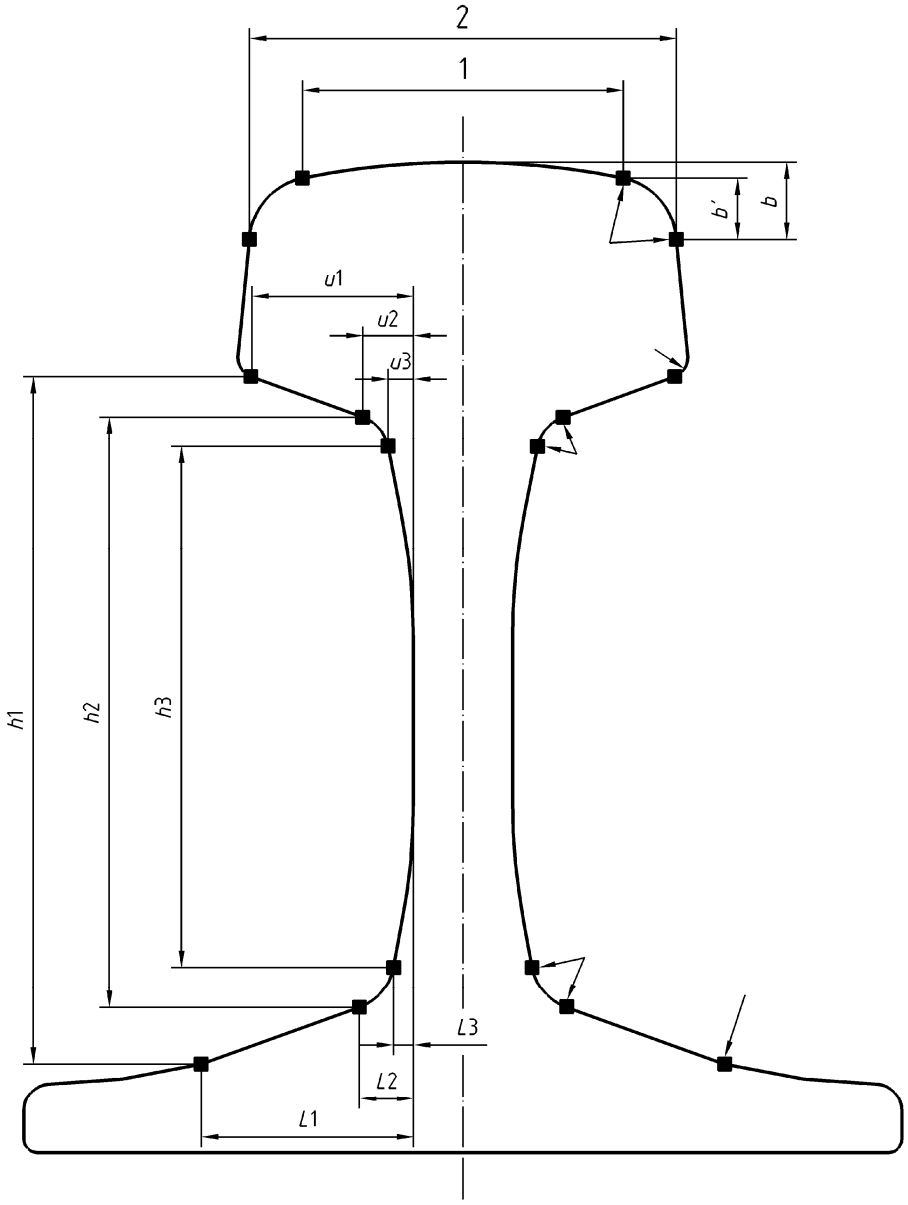
1 centre line of branding

Cross-sectional area	:	57,46	cm^2
Mass per metre	:	45,11	kg/m
Moment of inertia x-x axis	:	1 564,1	cm^4
Section modulus-Head	:	214,8	cm^3
Section modulus-Base	:	223,2	cm^3
Moment of inertia y-y axis	:	284,7	cm^4
Section modulus y-y axis	:	44,8	cm^3

Indicative dimensions : A = 43,096 mm

Figure A.13 — Rail profile 45E1

Dimensions in millimetres

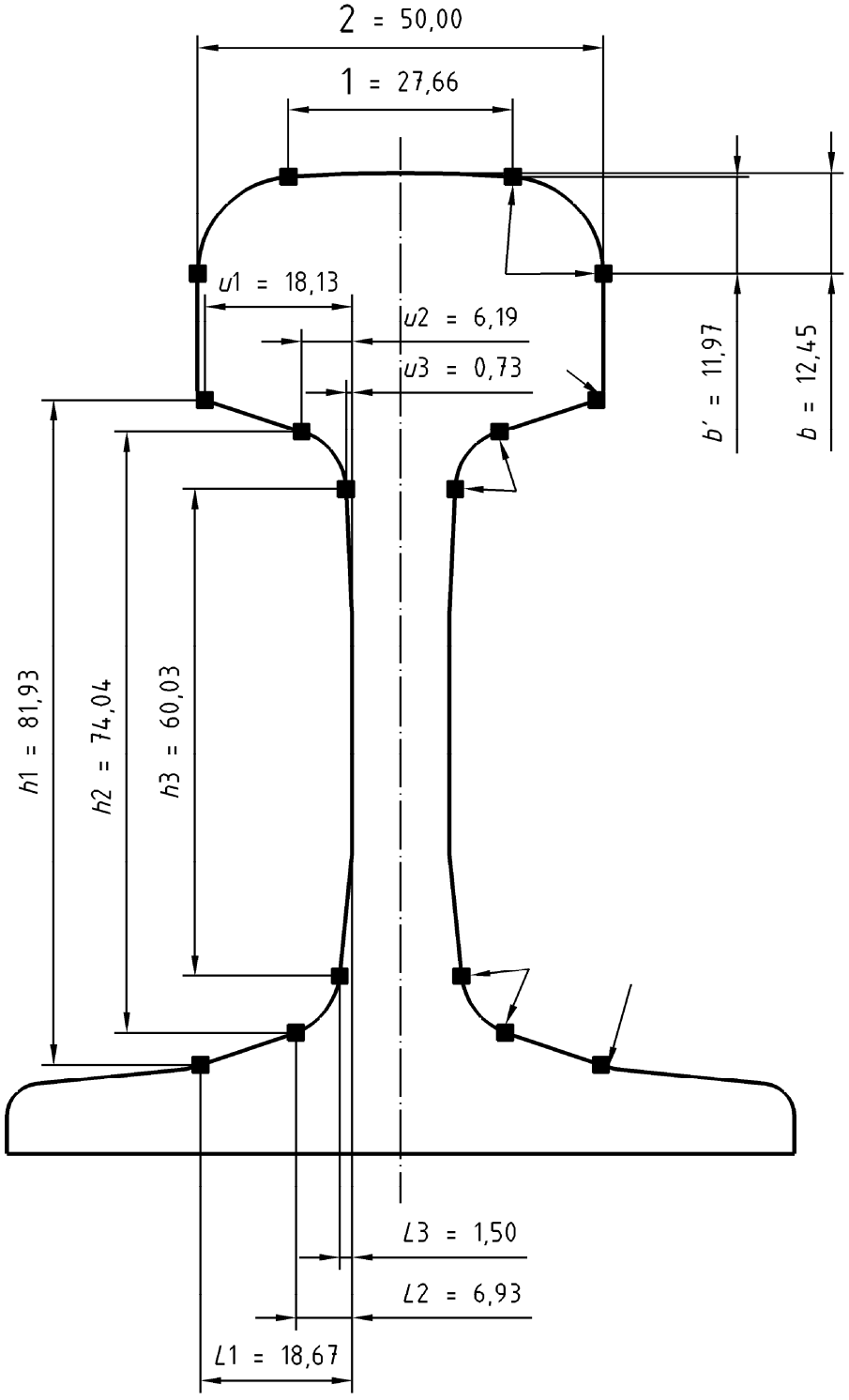


Key

1 centre line of branding

Cross-sectional area	:	57,98	cm^2
Mass per metre	:	45,51	kg/m
Moment of inertia x-x axis	:	1 535,9	cm^4
Section modulus-Head	:	212,3	cm^3
Section modulus-Base	:	223,8	cm^3
Moment of inertia y-y axis	:	297,0	cm^4
Section modulus y-y axis	:	47,1	cm^3
Indicative dimensions :	A = 20,060 mm		
	B = 48,886 mm		

Figure A.14 — Rail profile 45E2



Key

- Transition point 0,01 mm

Figure A.15 — Principal rail transition references

Dimensions in millimetres

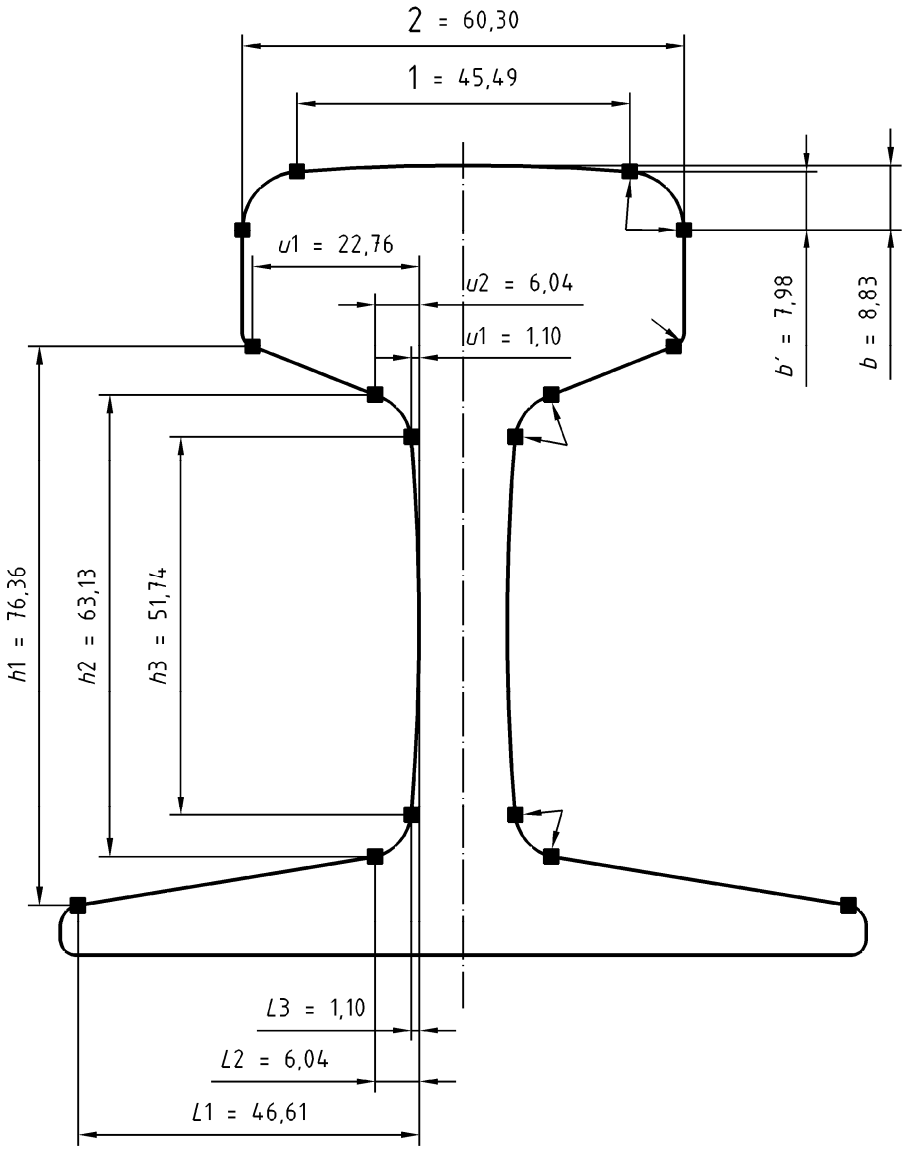


Figure A.16 — 27E1 Rail transition points

Dimensions in millimetres

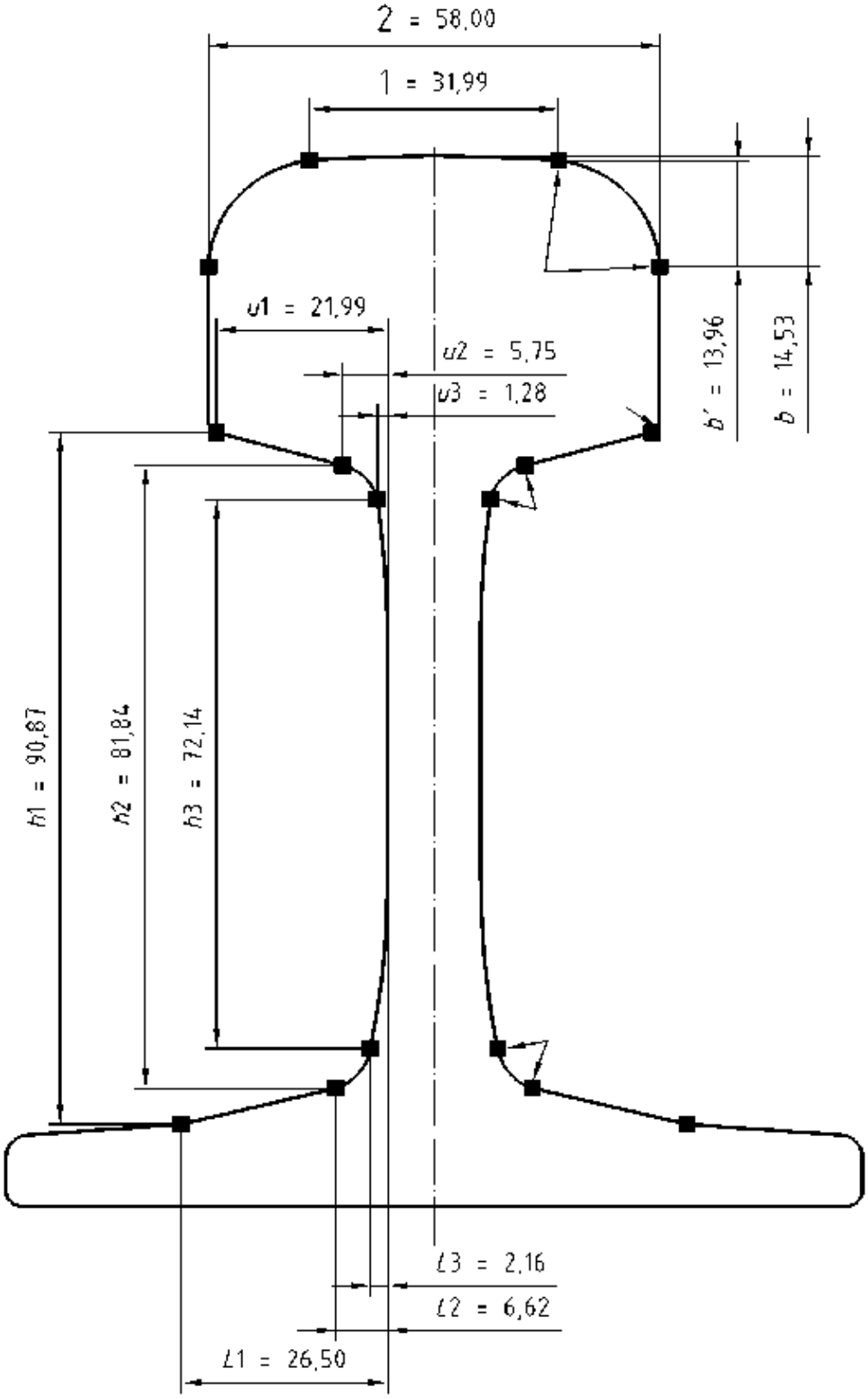


Figure A.17 — 30E1 Rail transition points

Dimensions in millimetres

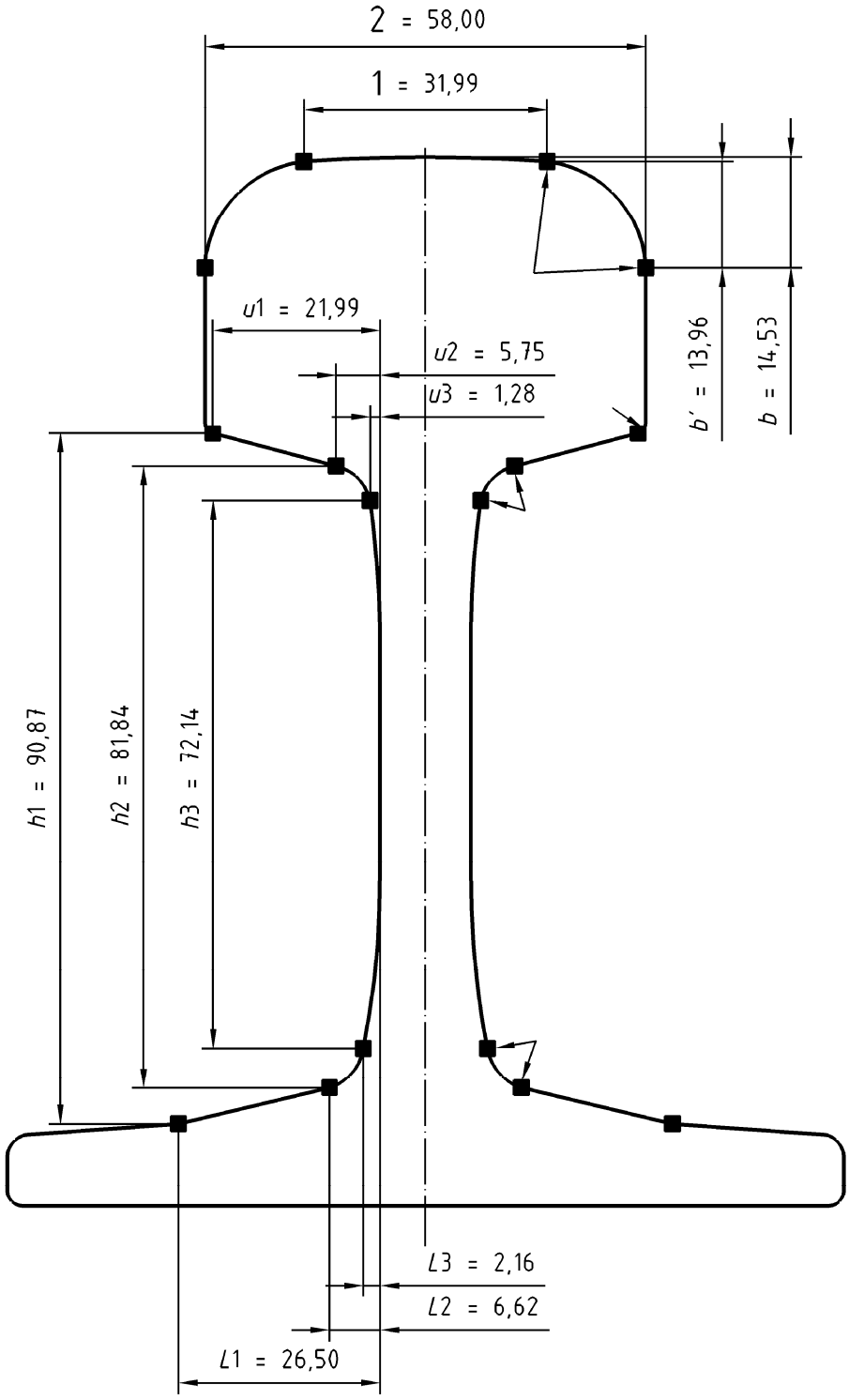


Figure A.18 — 30E2 Rail transition points

Dimensions in millimetres

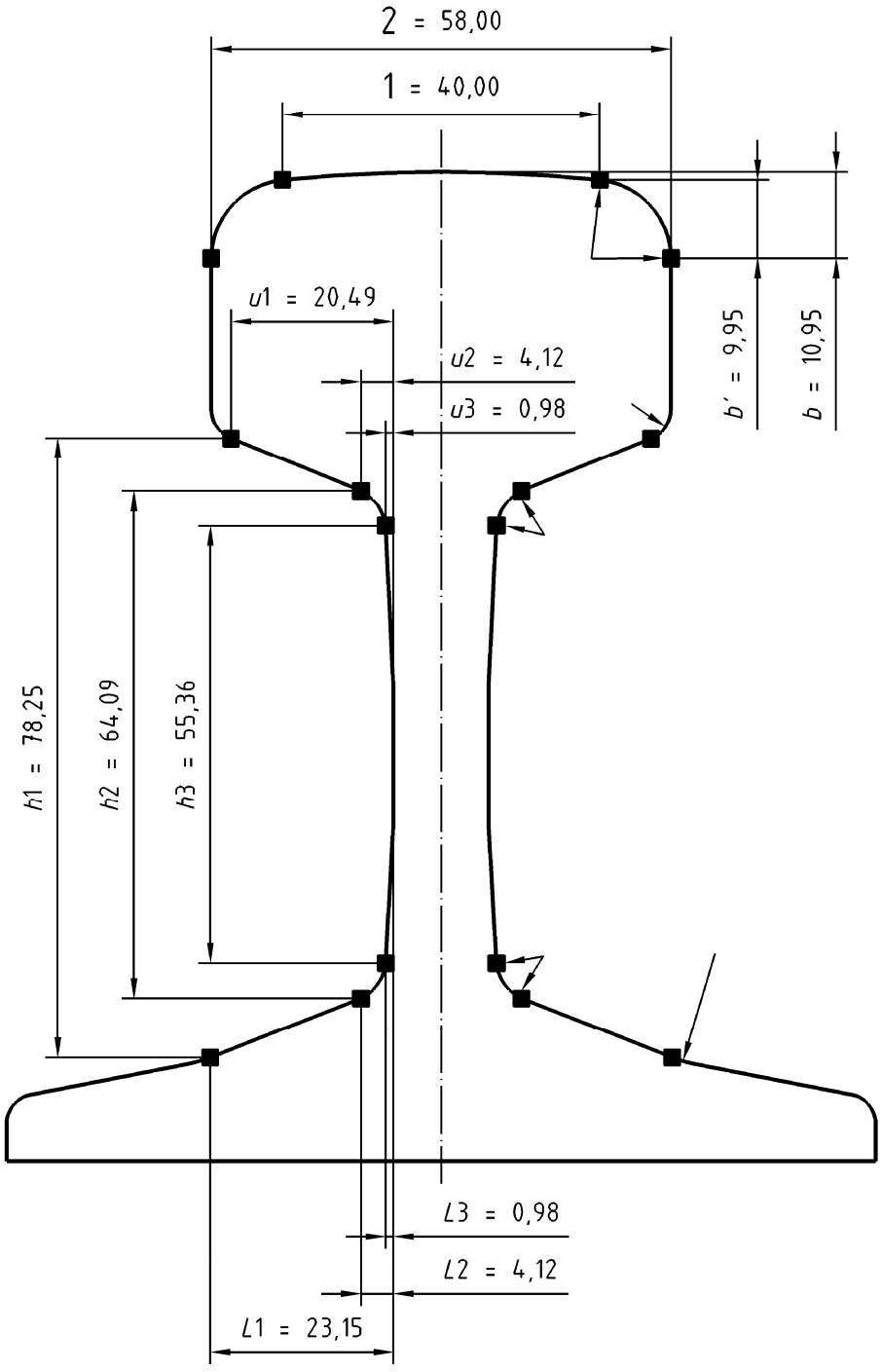


Figure A.19 — 33E1 Rail transition points

Dimensions in millimetres

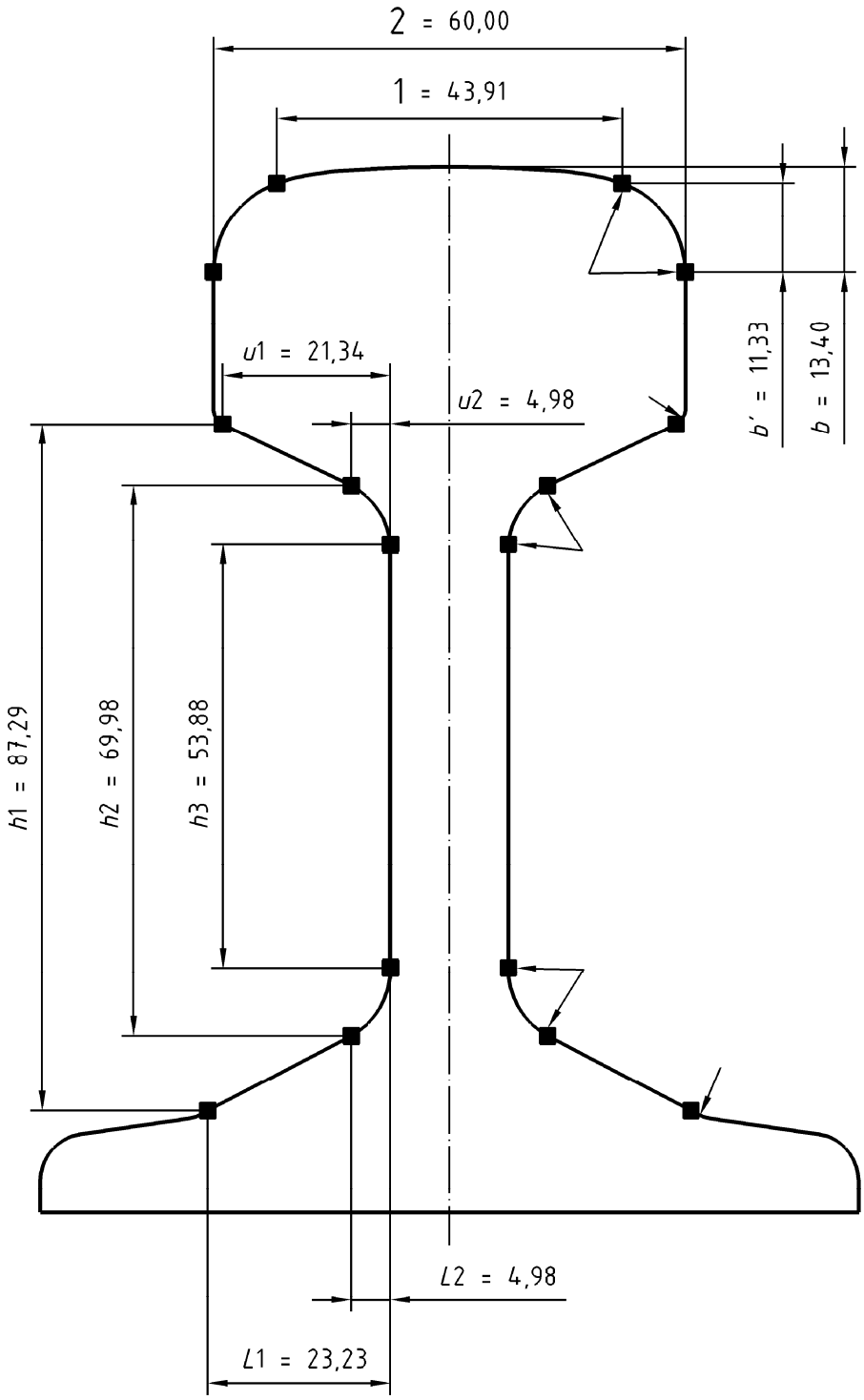


Figure A.20 — 35E1 Rail transition points

Dimensions in millimetres

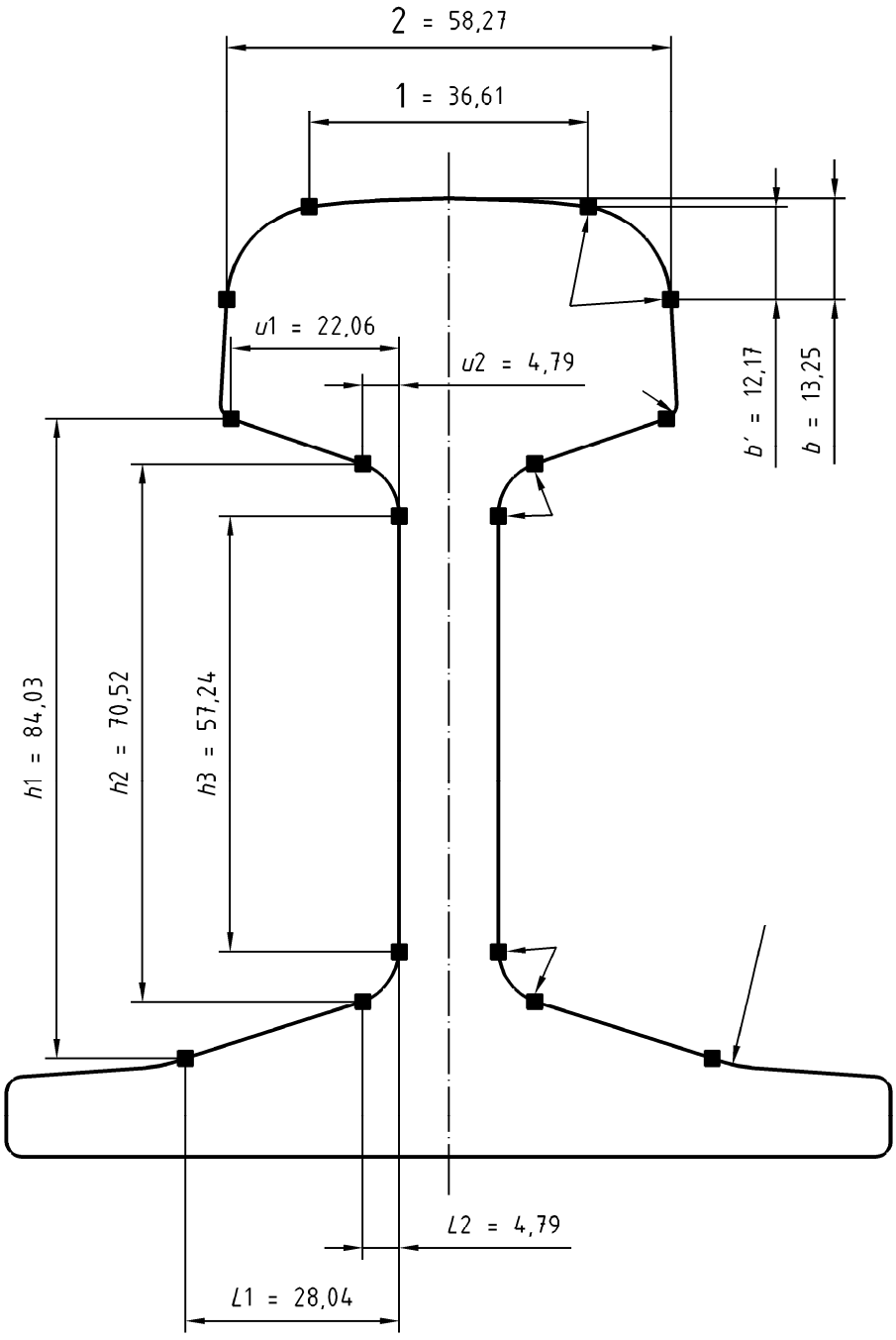


Figure A.21 — 36E1 Rail transition points

Dimensions in millimetres

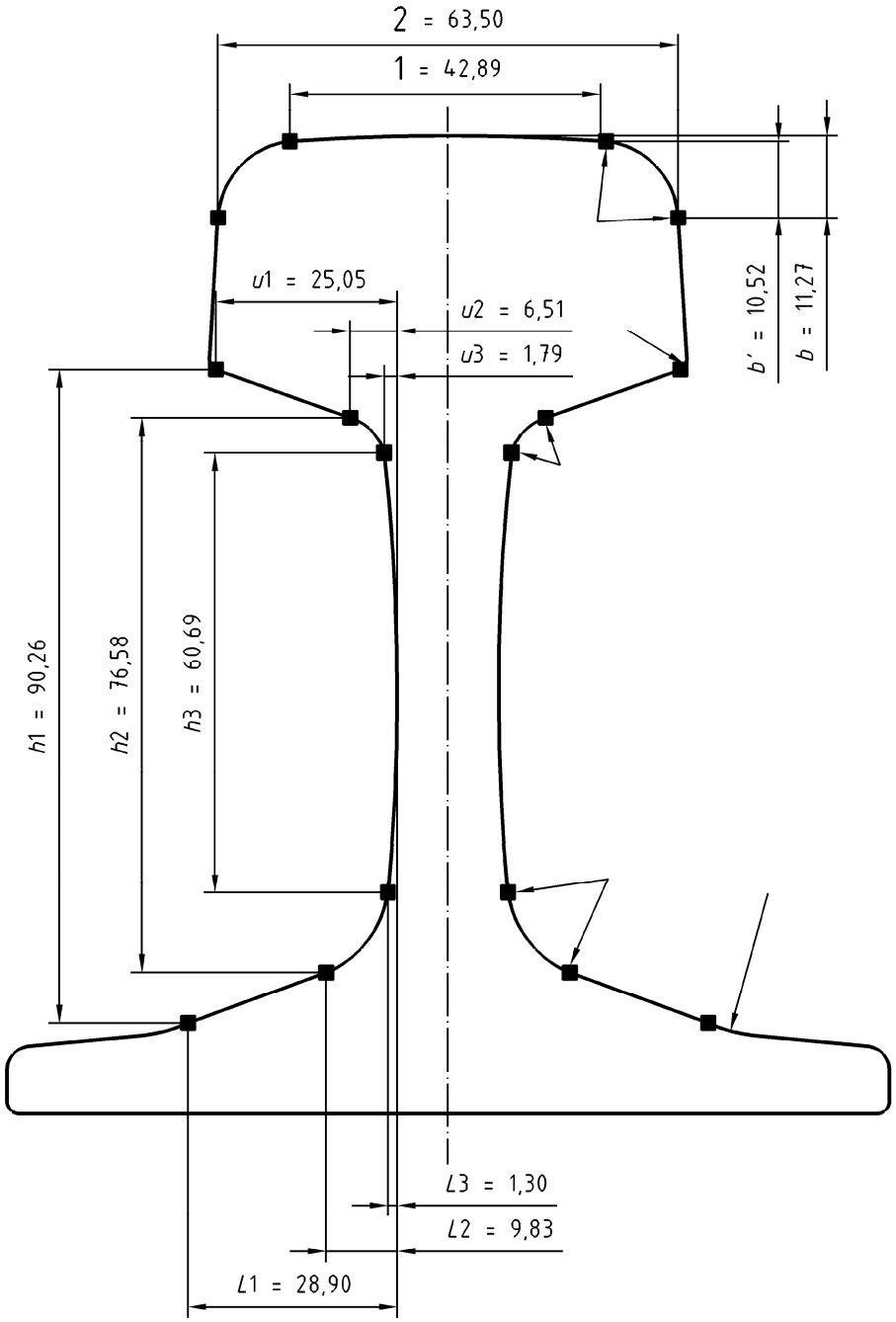


Figure A.22 — 36E2 Rail transition points

Dimensions in millimetres

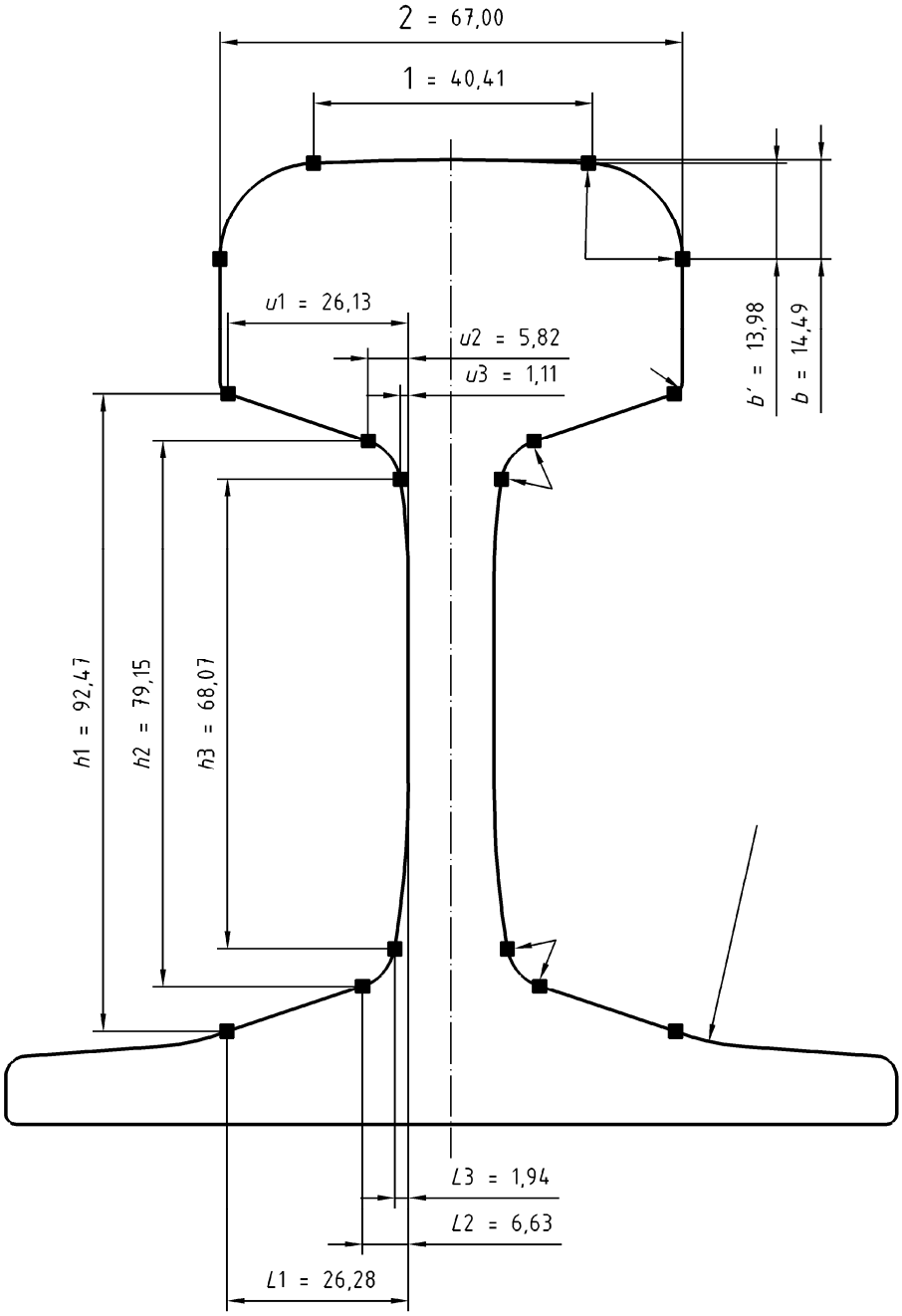


Figure A.23 — 39E1 Rail transition points

Dimensions in millimetres

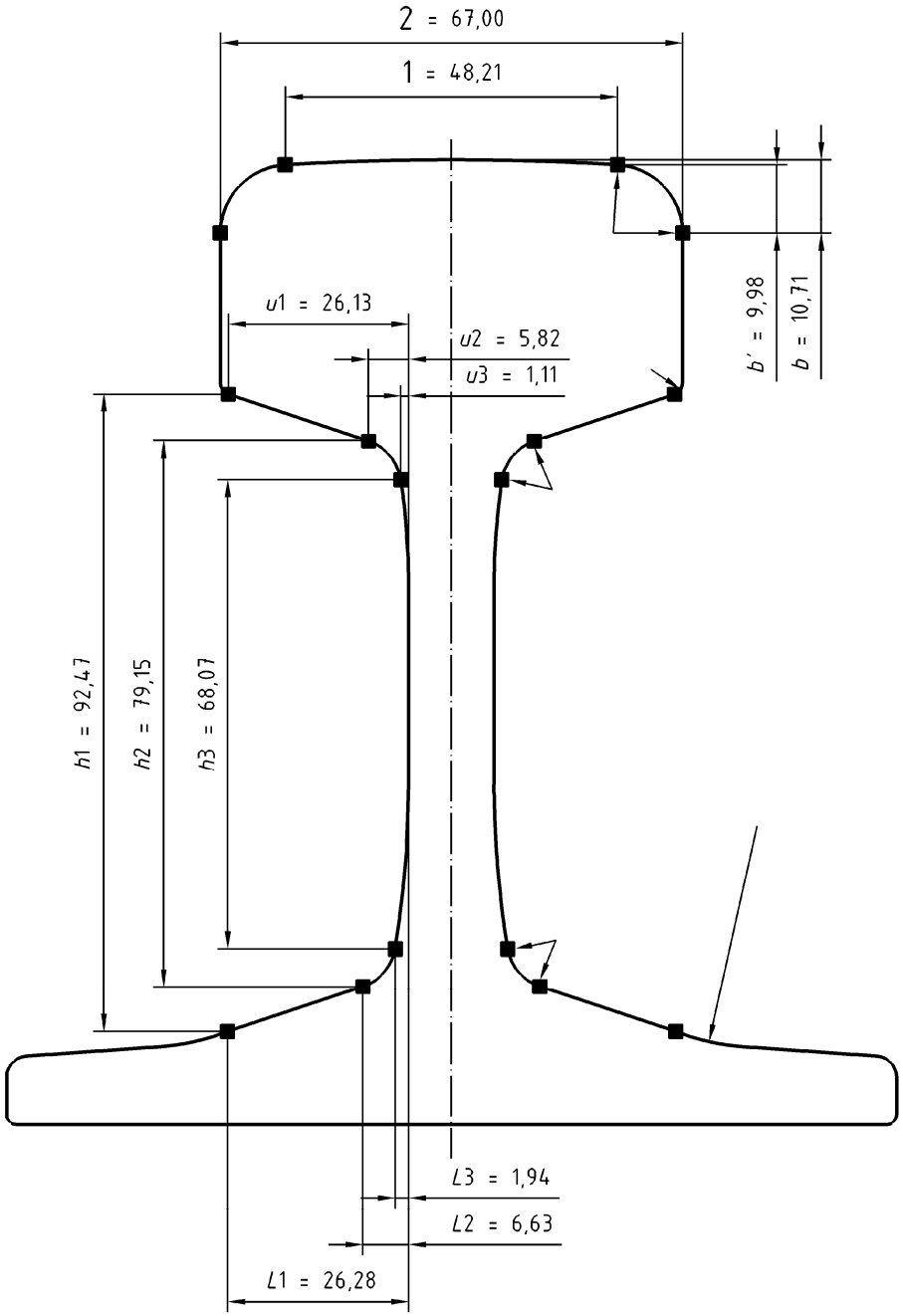


Figure A.24 — 40E1 Rail transition points

Dimensions in millimetres

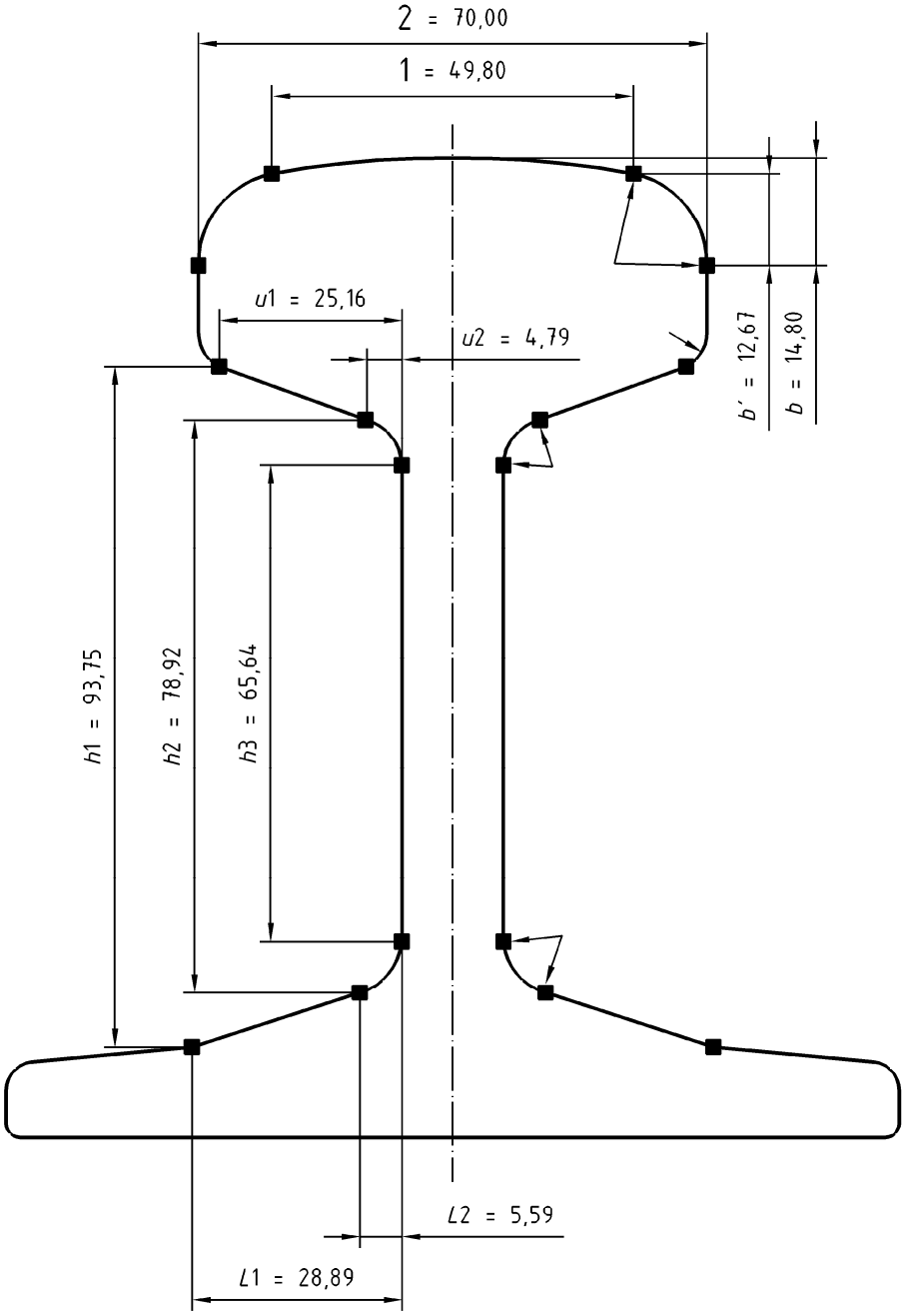


Figure A.25 — 41E1 Rail transition points

Dimensions in millimetres

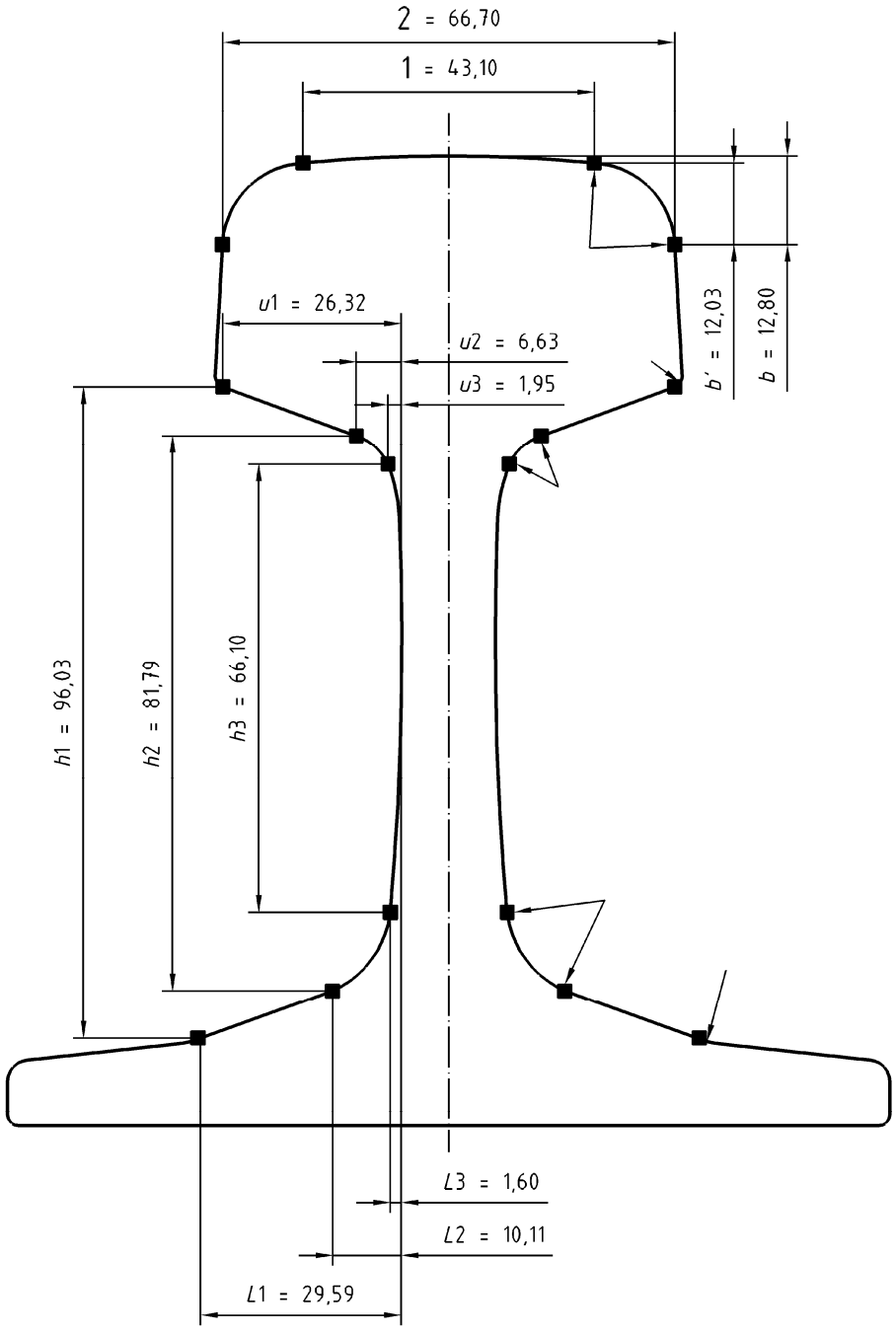


Figure A.26 — 43E1 Rail transition points

Dimensions in millimetres

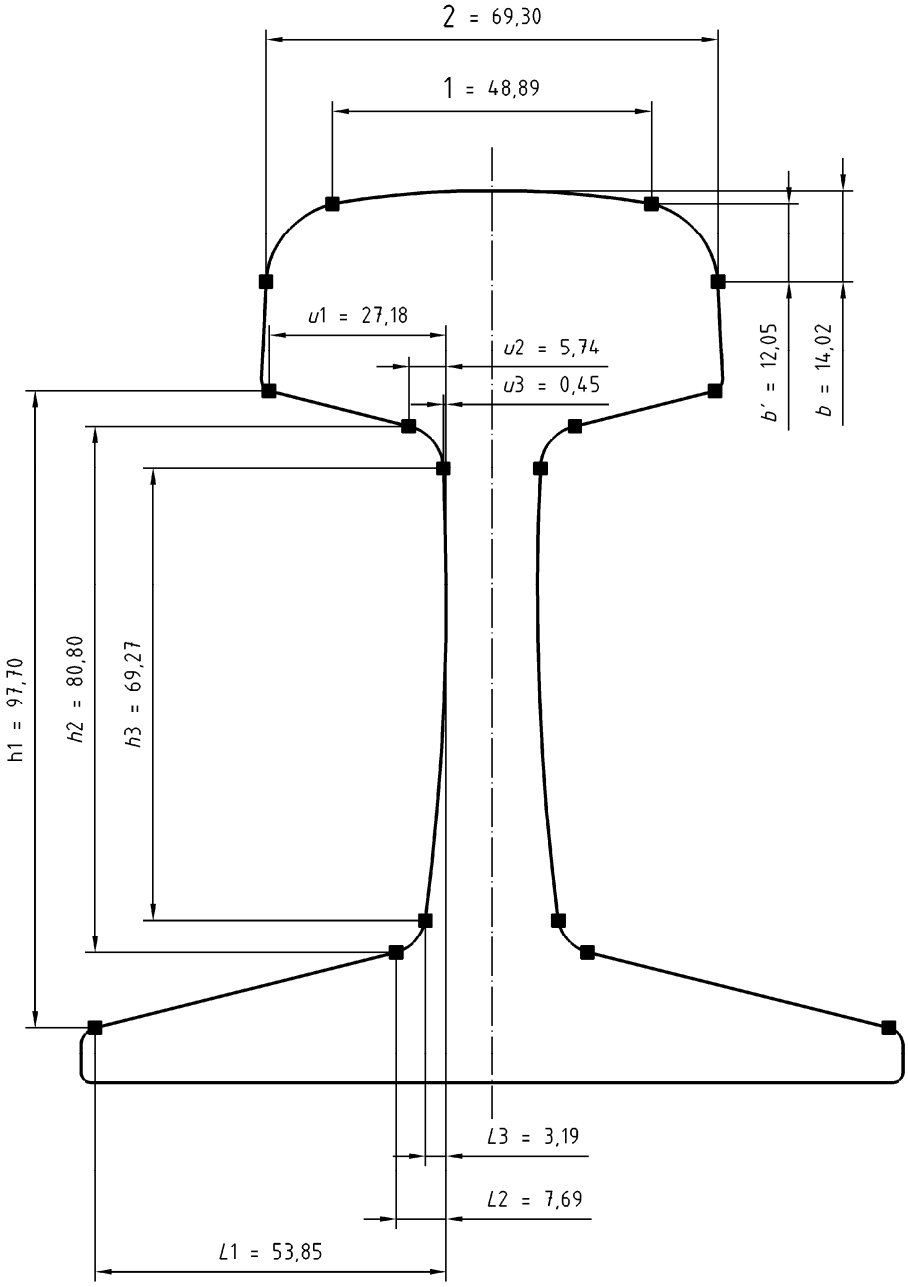


Figure A.27 — 45E1 Rail transition points

Dimensions in millimetres

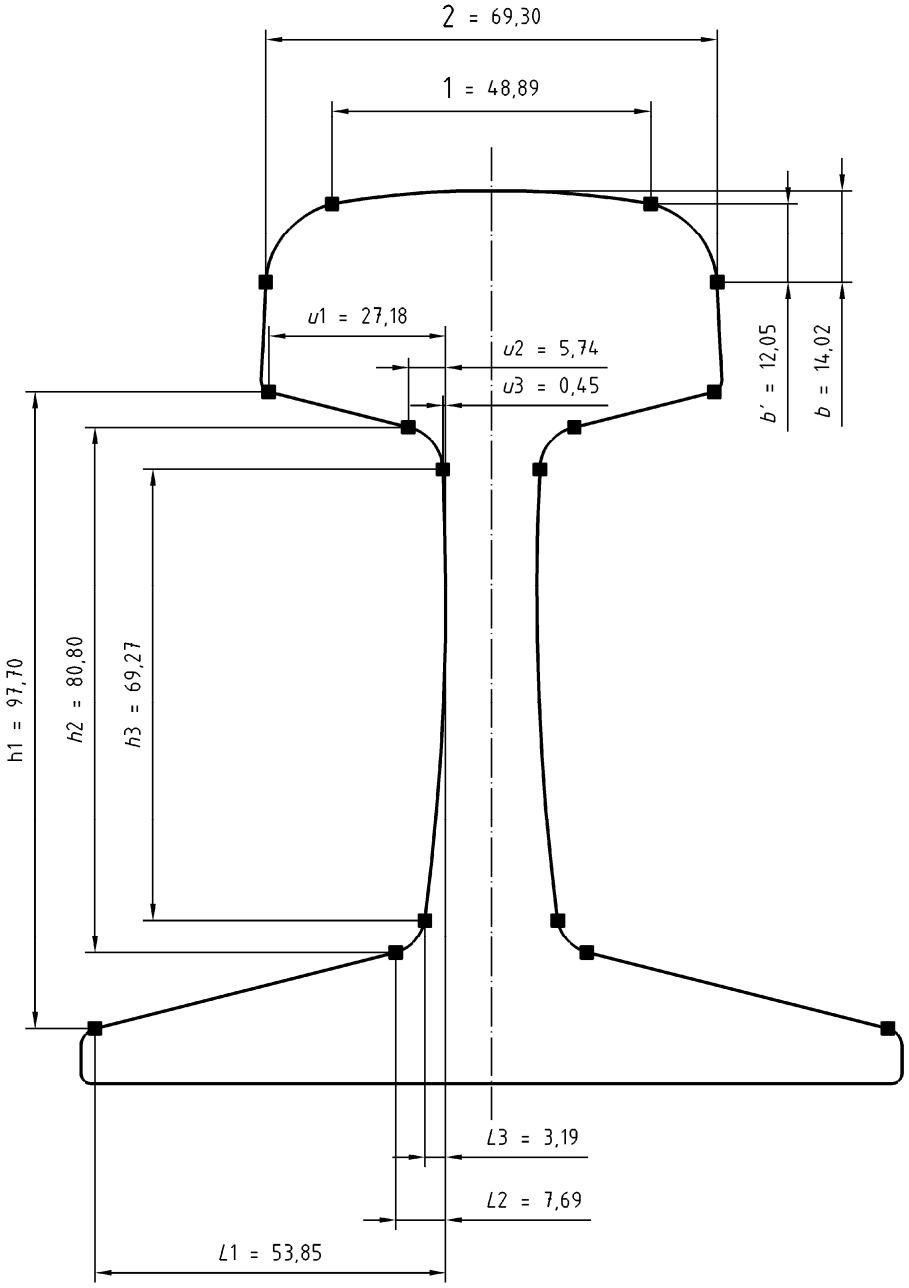


Figure A.28 — 45E2 Rail transition points

Annex B
(informative)

Comparison of steel designations referred to in this European Standard compared to those in EN 10027-1 and EN 10027-2

Steel grade in this European Standard	Steel name according to EN 10027-1	Steel number according to EN 10027-2
R200	R200	1.0521
R220	R220	1.0524
R260	R260	1.0623
R320Cr	R320Cr	1.0915
R350HT	R350G1HT	1.0631

Bibliography

[1] EN 10027-1, *Designation systems for steels — Part 1: Steel names*

[2] EN 10027-2, *Designation systems for steel — Part 2: Numerical system*

[3] EN ISO 9001*, Quality management systems — Requirements* A1 *(ISO 9001:2008)* A1

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